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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

CATALOGUE AND INDEX

OF THE

PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY

1901 to 1903

BY

PHILIP CREVELING WARMAN

WASHINGTON
GOVERNMENT PRINTING OFFICE
1903

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., June 1, 1903.

SIR: I have the honor to transmit herewith the manuscript for a catalogue and index of the publications of the United States Geological Survey issued between March, 1901, and June, 1903, and to request that it be published in the Bulletin series.

Very respectfully.

P. C. WARMAN,
Editor.

Hon. CHARLES D. WALCOTT,
Director of United States Geological Survey.

INTRODUCTION.

This catalogue and index are supplemental to those published in 1901 as Bulletin No. 177. These begin where those end; but there will be found in this index some entries—additional and corrective—which refer to papers covered by Bulletin No. 177. The two bulletins constitute a general catalogue and index of the publications of the Geological Survey from its organization, in 1879, to the present time. It is hoped that within the next few years someone will have the time and the inclination to combine the two and bring the work down to date.

The indexing has been done in a desultory manner, as opportunity arose; and in the work the writer has had the assistance of other members of the editorial corps, viz, Messrs. Charles A. Mansuy, Laurence F. Schmeckebier, and George M. Wood.

P. C. W.

PUBLICATIONS CATALOGUED AND INDEXED HEREIN.

ANNUAL REPORTS:
- Twenty-second, four parts.
- Twenty-third.

MONOGRAPHS:
- Nos. XLI to XLV.

PROFESSIONAL PAPERS:
- Nos. 1 to 13.

BULLETINS:
- Nos. 177 to 214.

WATER-SUPPLY AND IRRIGATION PAPERS:
- Nos. 46 to 80.

MINERAL RESOURCES:
- For calendar year 1900.
- For calendar year 1901.

GEOLOGIC ATLAS OF UNITED STATES:
- Folios Nos. 71 to 90.

TOPOGRAPHIC MAPS:
- About 180 atlas sheets and other separate maps.

MISCELLANEOUS PUBLICATIONS:
- Six.

CATALOGUE AND INDEX OF PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY, 1901-1903.

By P. C. WARMAN.

CATALOGUE.

ANNUAL REPORTS.

Twenty-second Annual Report of the United States Geological Survey to the Secretary of the Interior 1900-01 Charles D. Walcott Director In four parts Part I.—Director's report and a paper on asphalt and bituminous rock deposits [Part II—Ore deposits; Part III.—Coal, oil, cement; Part IV.—Hydrography F. H. Newell, chief of division] [Vignette] Washington Government Printing Office 1901 [Pts. III and IV, 1902]

8°. 4 vols. 464 pp., 58 pls.; 888 pp., 82 pls.; 763 pp., 53 pls.; 690 pp., 65 pls.

Pt. I. Director's report and a paper on asphalt and bituminous rock deposits. 452 pp., 58 pls.

Director's report, pp. 1-207, pls. i-xxiv.

Asphalt and bituminous rock deposits of the United States, by G. H. Eldridge, pp. 209-452, pls. xxv-lviii.

Index, pp. 453-464.

Pt. II. Ore deposits. 888 pp., 82 pls.

Old tungsten mine at Trumbull, Conn., by W. H. Hobbs, pp. 7-22, pls. i-v.

Preliminary report on the lead and zinc deposits of the Ozark region, by H. F. Bain, with an introduction by C. R. Van Hise, and chapters on the physiography and geology, by G. I. Adams, pp. 23-228, pls. vi-xxv.

The ore deposits of the Rico Mountains, Colorado, by F. L. Ransome, pp. 229-398, pls. xxvi-xli.

Geology and ore deposits of Elkhorn mining district, Jefferson County, Mont., by W. H. Weed, with an appendix on the microscopical petrography, by J. Barrell, pp. 399-550, pls. xlii-lxii.

The gold belt of the Blue Mountains of Oregon, by Waldemar Lindgren, pp. 551-776, pls. lxiii-lxxviii.

The ore deposits of Monte Cristo, Wash., by J. E. Spurr, pp. 777-866, pls. lxxix-lxxxii.

Index, pp. 867-888.

Pt. III. Coal, oil, cement. 763 pp., 53 pls.

Coal fields of the United States, by C. W. Hayes, pp. 1–24, pl. i.

Atlantic coast Triassic coal field, by J. B. Woodworth, pp. 25–53, pls. ii–v.

Pennsylvania anthracite coal field, by H. H. Stoek, pp. 55–117, pls. vi–x.

Northern Appalachian coal field, by M. R. Campbell, David White, and R. M. Haseltine, pp. 119–226, pls. xi–xii.

Southern Appalachian coal field, by C. W. Hayes, pp. 227–263, pls. xiii–xv.

Eastern Interior coal field, by G. H. Ashley, pp. 265–305, pls. xvi–xix.

Northern Interior coal field, by A. C. Lane, pp. 307–331, pls. xx–xxi.

Western Interior coal field, by H. F. Bain, pp. 333–366, pls. xxii–xxiv.

Southwestern coal field, by J. A. Taff, pp. 367–413, pls. xxv–xxviii.

Rocky Mountain coal fields, by L. S. Storrs, pp. 415–471, pls. xxix–xxx.

Pacific Coast coal fields, by G. O. Smith, pp. 473–513, pls. xxxi–xxxiv.

Coal resources of Alaska, by A. H. Brooks, pp. 515–571, pl. xxxv.

The Gaines oil field of northern Pennsylvania, by M. L. Fuller, pp. 573–627, pls. xxxvi–xliii.

Portland cement industry in Michigan, by I. C. Russell, pp. 629–685, pls. xliv–xlvi.

Chalk of southwestern Arkansas, by J. A. Taff, pp. 687–742, pls. xlvii–liii.

Index, pp. 743–763.

Pt. IV. Hydrography. 690 pp., 65 pls.

Report of progress of stream measurements for the calendar year 1900, by F. H. Newell, pp. 9–506, pls. i–xxxvi.

Hydrography of the American isthmus, by A. P. Davis, pp. 507–630, pls. xxxvii–l.

The High Plains and their utilization (concluded), by W. D. Johnson, pp. 631–669, pls. li–lxv.

Index, pp. 671–690.

Twenty-third Annual Report of the Director of the United States Geological Survey to the Secretary of the Interior 1901–02 [Vignette] Washington Government Printing Office 1902

217 pp., 26 pls. An administrative report only.

A law of Congress approved May 16, 1902, requires the annual report of the Director to be confined to one volume. Such papers as have heretofore appeared in the Annual Report series are now published in the series of Professional Papers, Bulletins, and Water-Supply and Irrigation Papers.

MONOGRAPHS.

Department of the Interior Monographs of the United States Geological Survey Volume XLI [-XLV] [Seal of the Department] Washington Government Printing Office 1902 [-1903]

4°. 5 vols. Bound in dark-maroon cloth.

XLI. Glacial formations and drainage features of the Erie and Ohio basins, by Frank Leverett. 1902. 802 pp., 26 pls. Price, $1.75.

XLII. Carboniferous ammonoids of America, by J. P. Smith. 1903. 211 pp., 29 pls. Price, 85 cents.

XLIII. The Mesabi iron-bearing district of Minnesota, by C. K. Leith. 1903. 316 pp., 33 pls. Price, $1.50.

XLIV. Pseudoceratites of the Cretaceous, by Alpheus Hyatt, edited by T. W. Stanton. 1903. 351 pp., 47 pls. Price, $1.

XLV. The Vermilion iron-bearing district of Minnesota, with atlas, by J. M. Clements. 1903. 463 pp., 13 pls. Price, —.

PROFESSIONAL PAPERS.

Professional Paper No. 1 [-13] Series A, Economic geology, 16 B, Descriptive geology, 20 Department of the Interior United States Geological Survey Charles D. Walcott, Director Preliminary report on the Ketchikan mining district, Alaska with an introductory sketch of the geology of southeastern Alaska by Alfred Hulse Brooks [Survey design] Washington Government Printing Office 1902 [-1903]

4°. 13 brochures, "granite" covers.

1. Preliminary report on the Ketchikan mining district, Alaska, with an introductory sketch of the geology of southeastern Alaska, by A. H. Brooks. 1902. 120 pp., 2 pls.
2. Reconnaissance of the northwestern portion of Seward Peninsula, Alaska, by A. J. Collier. 1902. 70 pp., 11 pls.
3. Geology and petrography of Crater Lake National Park, by J. S. Diller and H. B. Patton. 1902. 167 pp., 19 pls.
4. The forests of Oregon, by Henry Gannett. 1902. 36 pp., 7 pls.
5. The forests of Washington, a revision of estimates, by Henry Gannett. 1902. 38 pp., 1 pl.
6. Forest conditions in the Cascade Range, Washington, between the Washington and Mount Rainier forest reserves, by F. G. Plummer. 1902. 42 pp., 11 pls.
7. Forest conditions in the Olympic Forest Reserve, Washington, from notes by Arthur Dodwell and T. F. Rixon. 1902. 110 pp., 20 pls.
8. Forest conditions in the northern Sierra Nevada, California, by J. B. Leiberg. 1902. 194 pp., 12 pls.
9. Forest conditions in the Cascade Range Forest Reserve, by A. D. Langille, F. G. Plummer, Arthur Dodwell, T. F. Rixon, and J. B. Leiberg, with an introduction by Henry Gannett. 1903. 298 pp., 41 pls.
10. Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska, by way of Dall, Kanuti, Allen, and Kowak rivers, by W. C. Mendenhall. 1902. 68 pp., 10 pls.
11. Clays of the United States east of the Mississippi River, by Heinrich Ries. 1903. 298 pp., 9 pls.
12. Geology of the Globe copper district, Arizona, by F. L. Ransome. 1903. 168 pp., 27 pls.
13. Drainage modifications in southeastern Ohio and adjacent parts of West Virginia and Kentucky, by W. G. Tight. 1903. 111 pp., 17 pls.

BULLETINS.

Department of the Interior Bulletin of the United States Geological Survey No. 177[-214] [Seal of the Department] Washington Government Printing Office 1901[-1903]

8°. 38 pamphlets, "granite" covers.

177. Catalogue and index of the publications of the United States Geological Survey, 1880–1901, by P. C. Warman. 1901. 858 pp. (Out of stock.)
178. The El Paso tin deposits, by W. H. Weed. 1901. 15 pp., 1 pl.
179. Bibliography and catalogue of the fossil Vertebrata of North America, by O. P. Hay. 1902. 868 pp.
180. The occurrence and distribution of corundum in the United States, by J. H. Pratt. 1901. 98 pp., 14 pls.
181. Results of primary triangulation and primary traverse, fiscal year 1900–1901, by H. M. Wilson, J. H. Renshawe, E. M. Douglas, and R. U. Goode. 1901. 240 pp., 1 map.
182. A report on the economic geology of the Silverton quadrangle, Colorado, by F. L. Ransome. 1901. 265 pp., 16 pls. (Out of stock.)
183. A gazetteer of Porto Rico, by Henry Gannett. 1901. 51 pp.
184. Oil and gas fields of the Western Interior and northern Texas coal measures and of the Upper Cretaceous and Tertiary of the western Gulf Coast, by George I. Adams. 1901. 64 pp., 10 pls. (Out of stock.)
185. Results of spirit leveling, fiscal year 1900–1901, by H. M. Wilson, J. H. Renshawe, E. M. Douglas, and R. U. Goode. 1901. 219 pp.
186. On pyrite and marcasite, by H. N. Stokes. 1901. 50 pp.
187. Geographic dictionary of Alaska, by Marcus Baker. 1901. 446 pp.
188. Bibliography of North American geology, paleontology, petrology, and mineralogy for the years 1892–1900, inclusive, by F. B. Weeks, 1902. 717 pp.
189. Index to North American geology, paleontology, petrology, and mineralogy for the years 1892–1900, inclusive, by F. B. Weeks. 1902. 337 pp.
190. A gazetteer of Texas, by Henry Gannett. 1902. 162 pp., 8 pls.
191. North American geologic formation names: Bibliography, synonymy, and distribution, by F. B. Weeks. 1902. 448 pp.
192. A gazetteer of Cuba, by Henry Gannett. 1902. 113 pp., 8 pls.
193. The geological relations and distribution of platinum and associated metals, by J. F. Kemp. 1902. 95 pp., 6 pls. (Out of stock.)
194. Northwest boundary of Texas, by Marcus Baker. 1902. 51 pp., 1 pl.
195. Structural details in the Green Mountain region and in eastern New York (second paper), by T. N. Dale. 1902. 22 pp., 4 pls.
196. Topographic development of the Klamath Mountains, by J. S. Diller. 1902. 69 pp., 13 pls.
197. The origin of certain place names in the United States, by Henry Gannett. 1902. 280 pp. (Out of stock.)
198. The Berea grit oil sand in the Cadiz quadrangle, Ohio, by W. T. Griswold. 1902. 43 pp., 1 pl.

199. Geology and water resources of the Snake River Plains of Idaho, by I. C. Russell. 1902. 192 pp., 25 pls.
200. Reconnaissance of the borax deposits of Death Valley and Mohave Desert, by M. R. Campbell. 1902. 23 pp., 1 pl.
201. Results of primary triangulation and primary traverse, fiscal year 1901-2, by H. M. Wilson, J. H. Renshawe, E. M. Douglas, and R. U. Goode. 1902. 164 pp., 1 pl.
202. Tests for gold and silver in shales from western Kansas, by Waldemar Lindgren. 1902. 21 pp.
203. Bibliography and index of North American geology, paleontology, petrology, and mineralogy for the year 1901, by F. B. Weeks. 1902. 144 pp.
204. Fossil flora of the John Day Basin, Oregon, by F. H. Knowlton. 1902. 153 pp., 17 pls.
205. Mollusca of the Buda limestone, by G. B. Shattuck, with an appendix on the corals of the Buda limestone, by T. W. Vaughan. 1903. 94 pp., 27 pls.
206. A study of the fauna of the Hamilton formation of the Cayuga Lake section in central New York, by H. F. Cleland. 1903. 112 pp., 5 pls.
207. The action of ammonium chloride upon silicates, by F. W. Clarke and George Steiger. 1902. 57 pp.
208. Descriptive geology of Nevada south of the fortieth parallel and adjacent portions of California, by J. E. Spurr. 1903. 229 pp., 8 pls.
209. The geology of Ascutney Mountain, Vermont, by R. A. Daly. 1903. 122 pp., 7 pls.
210. The correlation of geological faunas: a contribution to Devonian paleontology, by H. S. Williams. 1903. 147 pp., 1 pl.
211. Stratigraphy and paleontology of the Upper Carboniferous rocks of the Kansas section, by G. I. Adams, G. H. Girty, and David White. 1903. 123 pp., 4 pls.
212. Oil fields of the Texas-Louisiana Gulf Coastal Plain, by C. W. Hayes and William Kennedy. 1903. 174 pp., 11 pls.
213. Contributions to economic geology, 1902; S. F. Emmons and C. W. Hayes, geologists in charge. 1903. 449 pp.
214. Geographic tables and formulas, compiled by Samuel S. Gannett. 1903. 284 pp.

WATER-SUPPLY AND IRRIGATION PAPERS.

Department of the Interior Water-Supply and Irrigation Papers of the United States Geological Survey No. 46 [–80] [Seal of the Department] Washington Government Printing Office 1901 [–1903]

8°. 35 pamphlets, "terra-cotta" covers.

46. Physical characteristics of Kern River, California, by F. H. Olmsted; and Reconnaissance of Yuba River, California, by Marsden Manson. 1901. 57 pp., 8 pls.
47. Operations at river stations, 1900, Part I. 1901. 100 pp.
48. Operations at river stations, 1900, Part II. 1901. 101–196 pp.
49. Operations at river stations, 1900, Part III. 1901. 197–292 pp.
50. Operations at river stations, 1900, Part IV. 1901. 293–388 pp.
51. Operations at river stations, 1900, Part V. 1901. 389–488 pp.
52. Operations at river stations, 1900, Part VI. 1901. 489–575 pp.
53. Geology and water resources of Nez Perce County, Idaho, Part I, by I. C. Russell. 1901. 86 pp., 10 pls.
54. Geology and water resources of Nez Perce County, Idaho, Part II, by I. C. Russell. 1901. 87–141 pp.
55. Geology and water resources of a portion of Yakima County, Wash., by G. O. Smith. 1901. 68 pp., 7 pls.
56. Methods of stream measurement. 1901. 51 pp., 12 pls.
57. Preliminary list of deep borings in the United States, Part I, by N. H. Darton. 1902. 60 pp. (Out of stock.)
58. Storage of water on King River, California, by J. B. Lippincott. 1902. 100 pp., 32 pls. (Out of stock.)
59. Development and application of water in southern California, Part I, by J. B. Lippincott. 1902. 95 pp., 11 pls. (Out of stock.)
60. Development and application of water in southern California, Part II, by J. B. Lippincott. 1902. 96–140 pp. (Out of stock.)
61. Preliminary list of deep borings in the United States, Part II, by N. H. Darton. 1902. 67 pp. (Out of stock.)
62. Hydrography of the Southern Appalachian Mountain region, Part I, by H. A. Pressey. 1902. 95 pp., 25 pls. (Out of stock.)
63. Hydrography of the Southern Appalachian Mountain region, Part II, by H. A. Pressey. 1902. 96–190 pp., pls. 26–44. (Out of stock.)
64. Accuracy of stream measurements, by E. C. Murphy. 1902. 99 pp., 4 pls. (Out of stock.)
65. Operations at river stations, 1901, Part I. (East of Mississippi River.) 1902. 334 pp.
66. Operations at river stations, 1901, Part II. (West of Mississippi River.) 1902. 188 pp.
67. The motions of underground waters, by C. S. Slichter. 1902. 106 pp., 8 pls.

68. Water storage in the Truckee Basin, California-Nevada, by L. H. Taylor. 1902. 90 pp., 8 pls.
69. Water powers of the State of Maine, by H. A. Pressey. 1902. 124 pp., 14 pls.
70. Geology and water resources of the Patrick and Goshen Hole quadrangles, Wyoming, by G. I. Adams. 1902. 50 pp., 11 pls.
71. Irrigation systems of Texas, by T. U. Taylor. 1902. 137 pp., 9 pls.
72. Sewage pollution in the metropolitan area near New York City and its effect on inland water resources, by M. O. Leighton. 1902. 75 pp., 8 pls.
73. Water storage on Salt River, Arizona, by A. P. Davis. 1902. 54 pp., 25 pls.
74. Water resources of the State of Colorado, by A. L. Fellows. 1902. 151 pp., 14 pls.
75. Report of progress of stream measurements for calendar year 1901, by F. H. Newell. 1903. 246 pp., 13 pls.
76. Observations on the flow of rivers in the vicinity of New York City, by H. A. Pressey. 1903. 108 pp., 13 pls.
77. Water resources of Molakai, Hawaiian Islands, by Waldemar Lindgren. 1903. 62 pp., 4 pls.
78. Preliminary report on artesian basins in southwestern Idaho and southeastern Oregon, by I. C. Russell. 1903. 53 pp., 2 pls.
79. Normal and polluted waters in northeastern United States, by M. O. Leighton. 1903. 192 pp.
80. Relation of rainfall to run-off, by G. W. Rafter. 1903. 104 pp.

MINERAL RESOURCES.

Department of the Interior United States Geological Survey Charles D. Walcott, Director Mineral resources of the United States Calendar year 1900 David T. Day chief of division of mining and mineral resources [Survey design] Washington Government Printing Office 1901

8°. 927 pp. Bound in black cloth. By act of Congress approved March 3, 1901, the report on mineral resources was again made an independent publication.

Introduction, pp. 11-12.
Summary of the mineral production of the United States in 1900, pp. 13-38.
Iron ores, by John Birkinbine, pp. 39-67.
Iron and steel at the close of the nineteenth century, by James M. Swank, general manager of the American Iron and Steel Association, pp. 69-104.
Gold and silver, by George E. Roberts, Director of the Mint, pp. 105-113.
Manganese ores, by John Birkinbine, pp. 115-140.
Copper, by Charles Kirchhoff, pp. 141-190.
Lead, by Charles Kirchhoff, pp. 191-211.
Zinc, by Charles Kirchhoff, pp. 213-227.
Aluminum and bauxite, by Joseph Hyde Pratt, pp. 229-231.
Platinum, pp. 233-234.
Quicksilver, pp. 235-238.
Lithium, pp. 239-243.
Nickel and cobalt, pp. 245-249.
Antimony, by Joseph Hyde Pratt, pp. 251-255.
Tungsten, molybdenum, uranium, and vanadium, by Joseph Hyde Pratt, pp. 257-265.
An occurrence of stream tin in the York region, Alaska, by Alfred H. Brooks, pp. 267-271.
Coal, by Edward W. Parker, pp. 273-457.
Coke, by Edward W. Parker, pp. 459-536.
Petroleum, by F. H. Oliphant, pp. 537-627.
Natural gas, by F. H. Oliphant, pp. 629-651.
Asphaltum and bituminous rock, by Edward W. Parker, pp. 653-660.
Stone, pp. 661-692.
Clay products, by Jefferson Middleton, pp. 693-736.
Portland cement, by Spencer B. Newberry, pp. 737-744.
American rock cement, by Uriah Cummings, pp. 745-746.
Slag cement in Alabama, by Edwin C. Eckel, pp. 747-748.
Precious stones, by George F. Kunz, pp. 749-778.
Talc and soapstone, by Joseph Hyde Pratt, pp. 779-786.
Abrasive materials, by Joseph Hyde Pratt, pp. 787-801.
Phosphate rock, by Edward W. Parker, pp. 803-814.
Sulphur and pyrite, by Edward W. Parker, pp. 815-826.
Gypsum, by Edward W. Parker, pp. 827-833.

Salt, by Edward W. Parker, pp. 835–847.
Mica, pp. 849–856.
Fluorspar, by Edward W. Parker, pp. 857–859.
Asbestos, by Joseph Hyde Pratt, pp. 861–868.
Lithographic stone, by S. J. Kubel, pp. 869–873.
Graphite, by Joseph Hyde Pratt, pp. 875–877.
Mineral paints, by Edward W. Parker, pp. 879–890.
Barytes, by Edward W. Parker, pp. 891–892.
Fuller's earth, pp. 893–894.
Flint and feldspar, p. 895.
Chromite, or chromitic iron ore, by Joseph Hyde Pratt, pp. 897–898.
Mineral waters, by A. C. Peale, pp. 899–905.
Index, pp. 907–927.

Department of the Interior United States Geological Survey Charles D. Walcott, Director Mineral resources of the United States Calendar year 1901 David T. Day chief of division of mining and mineral resources [Survey design] Washington Government Printing Office 1902

8°. 996 pp. Bound in black cloth.
Introduction, pp. 13–14.
Summary of the mineral production of the United States in 1901, pp. 15–41.
Iron ores, by John Birkinbine, pp. 43–72.
Statistics of the American iron trade for 1901, by James M. Swank, general manager of the American Iron and Steel Association, pp. 73–115.
Gold and silver, by George E. Roberts, Director of the Mint, pp. 117–126.
Manganese ores, by John Birkinbine, pp. 127–155.
Copper, by Charles Kirchhoff, pp. 157–198.
Lead, by Charles Kirchhoff, pp. 199–210.
Zinc, by Charles Kirchhoff, pp. 211–223.
Aluminum and bauxite, by Joseph Struthers, pp. 225–229.
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Greensand marl, by Arthur L. Parsons, pp. 823–827.
Sulphur and pyrite, by Joseph Struthers, pp. 829–842.
Gypsum, by Joseph Struthers, pp. 843–851.
Salt, by Joseph Struthers, pp. 853–865.
Bromine, by Joseph Struthers, pp. 867–868.
Borax, by Joseph Struthers, pp. 869–872.
Mica, by Joseph Hyde Pratt, pp. 873–878.
Fluorspar and cryolite, by Joseph Hyde Pratt, pp. 879–885.
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GEOLOGIC ATLAS OF UNITED STATES.

Department of the Interior United States Geological Survey Charles D. Walcott, Director Geologic Atlas of the United States Spanish Peaks folio Colorado [-Cranberry Tennessee] Index map [Map] List of sheets description topography historical geology igneous geology economic geology structure sections artesian water columnar sections special illustrations Folio 71 [-90] Library edition [or Field edition] Spanish Peaks [-Cranberry] Washington, D. C. Engraved and printed by the U. S. Geological Survey George W. Stose, editor of geologic maps S. J. Kübel, chief engraver 1901 [-1903]

Folio. 20 numbers (71-90).

Folios of Geologic Atlas of United States, 1901-1903.

No.	Name of folio.	State.	Limiting meridians.	Limiting parallels.	Area.	Price.
					Sq. m.	*Cents.*
7.	Spanish Peaks	Colorado	104° 30′-105°	37°-37° 30′	950	25
72	Charleston	West Virginia	81° 30′-82°	38°-38° 30′	938	25
73	Coos Bay	Oregon	124°-124° 30′	43°-43° 30′	871	25
74	Coalgate	Indian Territory	96°-96° 30′	34° 30′-35°	980	25
75	Maynardville	Tennessee	83° 30′-84°	36°-36° 30′	963	25
76	Austin	Texas	97° 30′-98°	30°-30° 30′	1,030	25
77	Raleigh	West Virginia	81°-81° 30′	37° 30′-38°	944	25
78	Rome	Georgia Alabama	85°-85° 30′	34°-34° 30′	986	25
79	Atoka	Indian Territory	96°-96° 30′	34°-34° 30′	986	25
80	Norfolk	Virginia North Carolina	75° 30′-76° 30′	36° 30′-37°	1,913	25
81	Chicago:					
	Riverside Chicago Desplaines Calumet	Illinois Indiana	87° 30′-88°	41° 30′-42°	892	50
82	Masontown-Uniontown	Pennsylvania	78° 30′-80°	39° 45′-40°	458	25
83	New York City:					
	Paterson Harlem Staten Island Brooklyn	New York New Jersey	73° 45′-74° 15′	40° 30′-41°	906	50
84	Ditney	Indiana	87°-87° 30′	38°-38° 30′	938	25
85	Oelrichs	South Dakota Nebraska	103°-103° 30′	43°-43° 30′	871	25
86	Ellensburg	Washington	120° 30′-121°	46° 30′-47°	820	25
87	Camp Clarke	Nebraska	103°-103° 30′	41° 30′-42°	892	25
88	Scotts Bluff	Nebraska	103° 30′-104°	41° 30′-42°	892	25
89	Port Orford	Oregon	124°-124° 30′	42° 30′-43°	878	25
90	Cranberry	Tennessee	81° 30′-82°	36°-36° 30′	963	25

TOPOGRAPHIC MAPS.

ATLAS SHEETS.

Atlas sheets, 1901–1903, arranged by States.

ALABAMA.

Name of atlas sheet.	Position of SE. corner of sheet. Lat.		Long.		Area covered.	Contour interval.	Scale.	Price.
	°	′	°	′		*Feet.*		*Cents.*
Wedowee (Ga.-Ala.)	33	00	85	00	¼ degree	50	1 : 125000	5
Wetumka	32	30	86	00	do	50	1 : 125000	5

ARIZONA.

Bisbee	31	15	109	45	1/16 degree	50	1 : 62500	5
Bradshaw Mountains	34	00	112	00	¼ degree	100	1 : 125000	5
Clifton	33	00	109	15	1/16 degree	100	1 : 62500	5
Florence	33	00	111	00	¼ degree	100	1 : 125000	5
Globe	33	15	110	45	1/16 degree	50	1 : 62500	5

ARKANSAS.

Camden	33	30	92	30	¼ degree	50	1 : 125000	5
Eureka Springs (Ark.-Mo.)	36	00	93	30	do	50	1 : 125000	5
Gurdon	33	30	93	00	do	50	1 : 125000	5
Winslow (Ark.-Ind. T.)	35	30	94	00	do	50	1 : 125000	5

CALIFORNIA.

Calabasas	34	00	118	30	1/16 degree	50	1 : 62500	5
Camulos	34	00	118	30	¼ degree	100	1 : 125000	5
Capistrano	33	00	117	30	do	100	1 : 125000	5
Corona	33	30	117	30	do	100	1 : 125000	5
Deep Creek	34	15	117	00	1/16 degree	50	1 : 62500	5
Fairoaks	38	30	121	15	do	10	1 : 62500	5
Hesperia	34	15	117	15	do	50	1 : 62500	5
Mount Lyell	37	30	119	00	¼ degree	100	1 : 125000	5
Napa	38	00	122	00	do	100	1 : 125000	5
Randsburg	35	15	117	30	1/16 degree	50	1 : 62500	5
Redding	40	30	122	00	¼ degree	100	1 : 125000	5
Redlands	34	00	117	00	1/16 degree	50	1 : 62500	5
Rock Creek	34	15	117	45	do	50	1 : 62500	5
San Antonio	34	15	117	30	do	50	1 : 62500	5
San Gorgonio	34	00	116	30	¼ degree	100	1 : 125000	5
San Luis Rey	33	00	117	00	do	100	1 : 125000	5
Santa Cruz	37	00	122	00	do	100	1 : 125000	5
Santa Susana	34	15	118	30	1/16 degree	50	1 : 62500	5
Tejon	34	30	118	30	¼ degree	100	1 : 125000	5

Atlas sheets, 1901–1903, arranged by States—Continued.

COLORADO.

Name of atlas sheet.	Position of SE. corner of sheet. Lat.		Long.		Area covered.	Contour interval.	Scale.	Price.
	°	′	°	′		*Feet.*		*Cents.*
Greeley	40	00	104	30	¼ degree	20	1 : 125000	5
Needle Mountains	37	30	107	30	1/16 degree	100	1 : 62500	5

CONNECTICUT.

Millbrook (N. Y.-Conn.)	41	45	73	30	1/16 degree	20	1 : 62500	5

DELAWARE.

Ocean City (Md.-Del.)	38	15	75	00	1/16 degree	10	1 : 62500	5
Pittsville (Md.-Del.)	38	15	75	15	.....do.....	10	1 : 62500	5
Salisbury (Md.-Del.)	38	15	75	30	.....do.....	10	1 : 62500	5

GEORGIA.

Wedowee (Ga.-Ala.)	33	00	85	00	¼ degree	50	1 : 125000	5

IDAHO.

Hamilton (Idaho-Mont.)	46	00	114	00	¼ degree	100	1 : 125000	5
Rathdrum	47	30	116	30	.....do.....	100	1 : 125000	5
Sandpoint	48	00	116	30	.....do.....	100	1 : 125000	5
Spokane (Idaho-Wash.)	47	30	117	00	.....do.....	100	1 : 125000	5

ILLINOIS.

Kahoka (Mo.-Iowa-Ill.)	40	00	91	30	¼ degree	20	1 : 125000	5
Mineral Point (Wis.-Ill.)	42	30	90	00	.....do.....	20	1 : 125000	5
O'Fallon (Mo.-Ill.)	38	30	90	30	.....do.....	50	1 : 125000	5
Rock Island (Iowa-Ill.)	41	30	90	30	.....do.....	20	1 : 125000	5

INDIAN TERRITORY.

Addington	34	00	97	30	¼ degree	50	1 : 125000	5
Alikchi	34	00	95	00	.....do.....	50	1 : 125000	5
Antlers	34	00	95	30	.....do.....	50	1 : 125000	5
Ardmore	34	00	97	00	.....do.....	50	1 : 125000	5
Denison (Ind. T.-Tex)	33	30	96	30	.....do.....	50	1 : 125000	5
Gainesville (Ind. T.-Tex)	33	30	97	00	.....do.....	50	1 : 125000	5
Lukfata	34	00	94	30	.....do.....	50	1 : 125000	5
Nowata	36	30	95	30	.....do.....	50	1 : 125000	5
Nuyaka	35	30	96	00	.....do.....	50	1 : 125000	5
Pauls Valley	34	30	97	00	.....do.....	50	1 : 125000	5
Rush Springs	34	30	97	30	.....do.....	50	1 : 125000	5
Winslow (Ark.-Ind. T.)	35	30	94	00	.....do.....	50	1 : 125000	5

Atlas sheets, 1901–1093, arranged by States—Continued.

INDIANA.

Name of atlas sheet.	Position of SE. corner of sheet. Lat.		Long.		Area covered.	Contour interval.	Scale.	Price.
	°	′	°	′		*Feet.*		*Cents.*
Boonville	38	00	87	15	1/16 degree	20	1 : 62500	5
Degonia Springs	38	00	87	00	do	20	1 : 62500	5
Ditney	38	00	87	00	1/4 degree	20	1 : 125000	5
Haubstadt	38	00	87	30	1/16 degree	20	1 : 62500	5
New Harmony	38	00	87	45	do	10	1 : 62500	5
Owensboro (Ind.-Ky.)	37	45	87	00	do	20	1 : 62500	5
Petersburg	38	15	87	15	do	20	1 : 62500	5
Princeton	38	15	87	30	do	20	1 : 62500	5
St. Meinrad	38	00	86	45	do	20	1 : 62500	5
Tell City (Ky.-Ind.)	37	45	86	45	do	20	1 : 62500	5
Velpen	38	15	87	00	do	20	1 : 62500	5

IOWA.

Elk Point (S. Dak.-Nebr.-Iowa)	42	30	96	30	1/4 degree	20	1 : 125000	5
Elkader Iowa-Wis.)	42	30	91	00	do	20	1 : 125000	5
Kahoka Mo.-Iowa-Ill	40	00	91	30	do	20	1 : 125000	5
Oelwein	42	30	91	30	do	20	1 : 125000	5
Rock Island (Ill.-Iowa)	41	30	90	30	do	20	1 : 125000	5
Stanwood	41	30	91	00	do	20	1 : 125000	5
Winthrop	42	00	91	30	do	20	1 : 125000	5

KENTUCKY.

Kenova (Ky.-W Va.-Ohio)	38	00	82	30	1/4 degree	100	1 : 125000	5
Owensboro Ind.-Ky.)	37	45	87	00	1/16 degree	20	1 : 62500	5
Tell City (Ky.-Ind.)	37	45	86	45	do	20	1 : 62500	5

MAINE.

Bangor	45	45	68	45	1/16 degree	20	1 : 62500	5
Castine	44	15	68	45	do	20	1 : 62500	5
Orono	44	45	68	30	do	20	1 : 62500	5

MARYLAND.

Belair Md.-Pa.	39	30	76	15	1/16 degree	20	1 : 62500	5
Bloodsworth Island	38	00	76	00	do		1 : 62500	5
Chestertown	39	00	76	00	do	20	1 : 62500	5
Crisfield (Md.-Va.)	37	45	75	45	do		1 : 62500	5
Deal Island	38	00	75	45	do	10	1 : 62500	5
Green Run (Md.-Va.)	38	00	75	00	do	10	1 : 62500	5
Hancock (Md W Va.-Pa.)	39	30	78	00	do	20	1 : 62500	5
Nanticoke	38	15	75	45	do	10	1 : 62500	5
Ocean City (Md.-Del.)	38	15	75	00	do	10	1 : 62500	5
Parkton (Md.-Pa.	39	30	76	30	do	20	1 : 62500	5
Pittsville Md.-Del.	38	15	75	15	do	10	1 : 62500	5
Princess Anne (Md.-Va.)	38	00	75	30	do	10	1 : 62500	5
Salisbury Md.-Del	38	15	75	30	do	10	1 : 62500	5
Snow Hill *Md. Va.)*	38	00	75	15	do	10	1 : 62500	5

Atlas sheets, 1901–1903, arranged by States—Continued.

MINNESOTA.

Name of atlas sheet.	Position of SE. corner of sheet. Lat.		Long.		Area covered.	Contour interval.	Scale.	Price.
	°	′	°	′		*Feet.*		*Cents.*
Anoka	45	00	93	15	1/16 degree	20	1 : 62500	5
White Bear	45	00	93	00	do	20	1 : 62500	5

MISSOURI.

De Soto	38	00	90	30	¼ degree	50	1 : 125000	5
Edina	40	00	92	00	do	20	1 : 125000	5
Eureka Springs (Ark.-Mo.)	36	00	93	30	do	50	1 : 125000	5
Kahoka (Mo.-Iowa-Ill.)	40	00	91	30	do	20	1 : 125000	5
O'Fallon (Mo.-Ill.)	38	30	90	30	do	50	1 : 125000	5
Sullivan	38	00	91	00	do	50	1 : 125000	5

MONTANA.

Aladdin (Wyo.-S. Dak.-Mont.)	44	30	104	00	¼ degree	50	1 : 125000	5
Bonner	46	30	113	30	do	100	1 : 125000	5
Browning	48	30	113	00	do	100	1 : 125000	5
Coopers Lake	47	00	112	30	do	100	1 : 125000	5
Hamilton (Idaho-Mont.)	46	00	114	00	do	100	1 : 125000	5

NEBRASKA.

Elk Point (S. Dak.-Nebr.-Iowa)	42	30	96	30	¼ degree	20	1 : 125000	5
Gothenburg	40	30	100	00	do	20	1 : 125000	5
North Platte	41	00	100	30	do	20	1 : 125000	5
Weeping Water	40	30	96	00	do	20	1 : 125000	5

NEW JERSEY.

Navesink	40	00	74	00	¼ degree	20	1 : 125000	5

NEW YORK.

Alexandria Bay	44	15	75	45	1/16 degree	20	1 : 62500	5
Babylon	40	30	73	15	do	20	1 : 62500	5
Big Moose	43	45	74	45	do	20	1 : 62500	5
Broadalbin	43	00	74	00	do	20	1 : 62500	5
Canandaigua	42	45	77	15	do	20	1 : 62500	5
Clayton	44	00	76	00	do	20	1 : 62500	5
Clyde	43	00	76	45	do	20	1 : 62500	5
Cortland	42	30	76	00	do	20	1 : 62500	5
Geneva	42	45	76	45	do	20	1 : 62500	5
Genoa	42	30	76	30	do	20	1 : 62500	5
Grindstone	44	15	76	00	do	20	1 : 62500	5
Hammondsport	42	15	77	00	do	20	1 : 62500	5
Kinderhook	42	15	73	30	do	20	1 : 62500	5
Luzerne	43	15	73	45	do	20	1 : 62500	5
Mettawee (N. Y.-Vt.)	43	00	73	00	¼ degree	40	1 : 125000	5
Millbrook (N. Y.-Conn.)	41	45	73	30	1/16 degree	20	1 : 62500	5
Morrisville	42	45	75	30	do	20	1 : 62500	5

Atlas sheets, 1901–1903, arranged by States—Continued.

NEW YORK—Continued.

Name of atlas sheet.	Position of SE. corner of sheet. Lat.		Long.		Area covered.	Contour interval.	Scale.	Price.
	°	′	°	′		Feet.		Cents.
Naples	42	30	77	15	1/16 degree	20	1 : 62500	5
Newburg	41	30	74	00	do	20	1 : 62500	5
Northport	40	45	73	15	do	20	1 : 62500	5
Norwich	42	30	75	30	do	20	1 : 62500	5
Owego	42	00	76	15	do	20	1 : 62500	5
Penn Yan	42	30	77	00	do	20	1 : 62500	5
Phelps	42	45	77	00	do	20	1 : 62500	5
Phoenicia	42	00	74	15	do	20	1 : 62500	5
Pultneyville	43	15	77	00	do	20	1 : 62500	5
Raquette Lake	43	45	74	30	do	20	1 : 62500	5
Richfield Springs	42	45	74	45	do	20	1 : 62500	5
Saratoga	43	00	73	45	do	20	1 : 62500	5
Schunemunk	41	15	74	00	do	20	1 : 62500	5
Sodus Bay	43	15	76	45	do	20	1 : 62500	5
Theresa	44	00	75	45	do	20	1 : 62500	5
Waverly	42	00	76	30	do	20	1 : 62500	5
Weedsport	43	00	76	30	do	20	1 : 62500	5

NORTH CAROLINA.

Kenly	35	30	78	00	1/16 degree	20	1 : 62500	5
Parmele	35	45	77	15	do	10	1 : 62500	5
Tarboro	35	45	77	30	do	10	1 : 62500	5
Williamston	35	45	77	00	do	10	1 : 62500	5

OHIO.

Fostoria	41	00	83	15	1/16 degree	10	1 : 62500	5
Guyandot (W. Va.–Ohio)	38	15	82	15	do	20	1 : 62500	5
Kenova (Ky.–W. Va.–Ohio)	38	00	82	30	1/4 degree	100	1 : 125000	5
Oberlin	41	15	82	00	1/16 degree	10	1 : 62500	5
Put-in-Bay	41	30	82	45	do	10	1 : 62500	5
Wheeling (W. Va.–Ohio–Pa.)	40	00	80	30	do	20	1 : 62500	5

OREGON.

Baker City	44	30	117	30	1/4 degree	100	1 : 125000	5
Sumpter	44	30	118	00	do	100	1 : 125000	5

PENNSYLVANIA.

Belair (Md.–Pa.)	39	30	76	15	1/16 degree	20	1 : 62500	5
Boyertown	40	15	75	30	do	20	1 : 62500	5
Brownsville	40	00	79	45	do	20	1 : 62500	5
Chambersburg	39	45	77	30	do	20	1 : 62500	5
Connellsville	40	00	79	30	do	20	1 : 62500	5
Everett	40	00	78	15	do	20	1 : 62500	5
Hancock (Md.–W. Va.–Pa.)	39	30	78	00	do	20	1 : 62500	5
Indiana	40	30	79	00	do	20	1 : 62500	5

Atlas sheets, 1901–1903, arranged by States—Continued.

PENNSYLVANIA—Continued.

Name of atlas sheet.	Position of SE. corner of sheet. Lat.		Long.		Area covered.	Contour interval.	Scale.	Price.
	°	′	°	′		*Feet.*		*Cents.*
Kittanning	40	45	79	30	1/16 degree	20	1 : 62500	5
Latrobe	40	15	79	15	do	20	1 : 62500	5
Mercersburg	39	45	77	45	do	20	1 : 62500	5
Morgantown (W. Va.-Pa.)	39	30	79	45	do	20	1 : 62500	5
Parkton (Md.-Pa.)	39	30	76	30	do	20	1 : 62500	5
Slatington	40	30	75	30	do	20	1 : 62500	5
Tioga	41	45	77	00	do	20	1 : 62500	5
Wernersville	40	15	76	00	do	20	1 : 62500	5
Wheeling (W. Va.-Ohio-Pa.)	40	00	80	30	do	20	1 : 62500	5

SOUTH DAKOTA.

Aladdin (Wyo.-S. D.-Mont.)	44	30	104	00	¼ degree	50	1 : 125000	5
Edgemont	43	00	103	30	do	50	1 : 125000	5
Elk Point (S. Dak.-Nebr.-Iowa)	42	30	96	30	do	20	1 : 125000	5
Newcastle (Wyo.-S. Dak.)	43	30	104	00	do	50	1 : 125000	5

TEXAS.

Cerro Alto	31	30	105	30	¼ degree	50	1 : 125000	5
Denison (Ind. T.-Tex.)	33	30	96	30	do	50	1 : 125000	5
Gainesville (Ind. T.-Tex.)	33	30	97	00	do	50	1 : 125000	5

UTAH.

Coalville	40	30	111	00	¼ degree	100	1 : 125000	5

VERMONT.

Mettawee (N. Y.-Vt.)	43	00	73	00	¼ degree	40	1 : 125000	5

VIRGINIA.

Crisfield (Md.-Va.)	37	45	75	45	1/16 degree		1 : 62500	5
Green Run (Md.-Va.)	38	00	75	00	do	10	1 : 62500	5
Princess Anne (Md.-Va.)	38	00	75	30	do	10	1 : 62500	5
Snow Hill (Md.-Va.)	38	00	75	15	do	10	1 : 62500	5

WASHINGTON.

Chelan	47	30	120	00	¼ degree	100	1 : 125000	5
Ellensburg	46	30	120	30	do	100	1 : 125000	5
Snoqualmie	47	00	121	00	do	100	1 : 125000	5
Spokane (Idaho-Wash.)	47	30	117	00	do	100	1 : 125000	5

Atlas sheets, 1901–1903, arranged by States—Continued.

WEST VIRGINIA.

Name of atlas sheet.	Position of SE. corner of sheet. Lat.		Long.		Area covered.	Contour interval.	Scale.	Price.
	°		°	′		Feet.		Cents.
Clarksburg	39	15	80	15	1/16 degree	20	1:62500	5
Fairmont	39	15	80	00	....do	20	1:62500	5
Guyandot (W. Va.-Ohio)	38	15	82	15	....do	20	1:62500	5
Hancock (Md.-W. Va.-Pa.)	39	30	78	00	....do	20	1:62500	5
Kenova (Ky.-W. Va.-Ohio)	38	00	82	30	½ degree	100	1:125000	5
Milton	38	15	82	00	1/16 degree	20	1:62500	5
Morgantown (W. Va.-Pa.)	39	30	79	45	....do	20	1:62500	5
Wheeling (W. Va.-Ohio-Pa.)	40	00	80	30	....do	20	1:62500	5

WISCONSIN.

Briggsville	43	30	89	30	1/16 degree	20	1:62500	5
Denzer	43	15	89	45	....do	20	1:62500	5
Elkader (Iowa-Wis.)	42	30	91	00	½ degree	20	1:125000	5
Mineral Point (Wis.-Ill.)	42	30	90	00	....do	20	1:125000	5
Poynette	43	15	89	15	1/16 degree	20	1:62500	5
The Dells	43	30	89	45	....do	20	1:62500	5

WYOMING.

Aladdin (Wyo.-S. D.-Mont.)	44	30	104	00	½ degree	50	1:125000	5
Fort McKinney	44	00	106	30	....do	100	1:125000	5
Mount Leidy	43	30	110	00	....do	100	1:125000	5
Newcastle (S. Dak.-Wyo.)	43	30	104	00	....do	50	1:125000	5

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GENERAL, SPECIAL, AND ECONOMIC MAPS.

ARIZONA:

Bisbee Special. Scale, 1 : 12000; contour interval, 20 feet. Shows location of copper mines in the Bisbee district.

Globe Special. Scale, 1 : 12000; contour interval, 20 feet. Shows location of mines and smelters in the Globe district.

CALIFORNIA:

Southern California. Scale, 1 : 250000; contour interval, 250 feet. Covers the southern part of the State, on reduced scale. Latitude, 33° 30′–34° 30′; longitude, 116° 30′–118° 30′.

COLORADO-WYOMING:

Encampment Special. Scale, 1 : 90000; contour interval, 100 feet. Latitude, 41°–41° 15′; longitude, 106° 45′–107° 15′.

IDAHO-MONTANA:

Cœur d'Alene Special. Scale, 1 : 62500; contour interval, 50 feet. Cœur d'Alene region, chiefly in northern Idaho.

INDIAN TERRITORY:

Map of the Territory. Scale, 1 : 500000; contour interval, 100 feet.

MISSOURI-KANSAS:

Joplin district. Scale, 1 : 62500; contour interval, 10 feet. Covers the region around Joplin for a north-south distance of about 15 miles and an east-west distance of about 25 miles.

MONTANA:

Marysville Special. Scale, 1 : 31250; contour interval, 50 feet. Covers the region around Marysville for a north-south distance of about 8 miles and an east-west distance of about 5 miles.

NEW YORK:

Niagara River and vicinity. Scale, 1 : 62500; contour interval, 20 feet. Covers portions of Niagara Falls, Tonawanda, Wilson, and Buffalo quadrangles.

TEXAS:

Terlingua Special. Scale, 1 : 50000; contour interval, 25 feet. Covers the region extending 12 miles eastward and 3 miles westward from Terlingua and about 5 miles in a north-south direction.

UTAH:

Bingham mining map. Scale, 1 : 20000; contour interval, 50 feet. Covers part of Tooele Valley quadrangle, in the vicinity of Bingham Canyon.

Park City Special. Scale, 1 : 25000; contour interval, 50 feet. Covers the region extending about 4 miles southward and 3 miles eastward and westward from Park City.

WISCONSIN:

Marathon Special. Scale, 1 : 125000; contour interval, 20 feet. Latitude, 44° 45′–45° 15′; longitude, 89° 45′–90° 15′.

Wausau Special. Scale, 1 : 125000; contour interval, 20 feet. Latitude, 44° 45′–45° 15′; longitude, 89° 15′–89° 45′.

MISCELLANEOUS PUBLICATIONS.

SPECIAL REPORTS ON ALASKA.

CAPE NOME AND NORTON BAY REGIONS.

Department of the Interior United States Geological Survey Charles D. Walcott, Director Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900 By Alfred H. Brooks, George B. Richardson, Arthur J. Collier and Walter C. Mendenhall Washington Government Printing Office 1901

Royal 8°. 222 pp., 23 pls. "Granite" cover. Published by authority of concurrent resolution of Congress of February 13, 1901. The documentary issue is House Doc. No. 547, 2d session, 56th Congress.

COPPER RIVER DISTRICT.

Department of the Interior United States Geological Survey Charles D. Walcott, Director The geology and mineral resources of a portion of the Copper River district, Alaska By Frank Charles Schrader and Arthur Coe Spencer Washington Government Printing Office 1901

Royal 8°. 94 pp., 13 pls. "Granite" cover. Published by authority of concurrent resolution of Congress of February 13, 1901. The documentary issue is House Doc. No. 546, 2d session, 56th Congress.

For other reports on Alaska, published within the time covered by this catalogue, see Twenty-second Annual, Pt. III, p. 515; Professional Papers, Nos. 1, 2, and 10; and Bulletin No. 187.

LOGARITHM TABLES.

Department of the Interior United States Geological Survey Charles D. Walcott, Director Five-place logarithms of natural numbers and circular functions expressed in arc and time Washington Government Printing Office 1901

Large 8°. 69 pp. Bound in brown cloth.

REGULATIONS.

United States Geological Survey Charles D. Walcott, Director Regulations of the United States Geological Survey third edition approved December 27, 1902, to take effect January 1, 1903. Washington Government Printing Office 1903.

16°. 52 pp. Bound in dark-blue leatherette.

INSTRUCTIONS.

United States Geological Survey Charles D. Walcott, Director Instructions relating to the work of the United States Geological Survey to take effect May 1, 1903 Washington Government Printing Office 1903

16°. 131 pp. Bound in red leatherette.

LIST OF PUBLICATIONS.

(9–320) Department of the Interior United States Geological Survey List of the publications of the United States Geological Survey Charles D. Walcott, Director [Design] Washington Government Printing Office 1903

8°. 47 pp. Blue cover.

Classification of Professional Papers, Bulletins, and Water-Supply Papers.

[PP = Professional Paper; B = Bulletin; WS = Water-Supply Paper.]

Series number.	A. Economic geology.	B. Descriptive geology.	C. Systematic geology and paleontology.	D. Petrography and mineralogy.	E. Chemistry and physics.	F. Geography.	G. Miscellaneous.	H. Forestry.	I. Irrigation.	J. Water storage.	K. Pumping water.	L. Quality of water.	M. General hydrographic investigations.	N. Water power.	O. Underground waters.	P. Hydrographic progress reports.
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[Abbreviations: Ann=Annual Report; Mon=Monograph; PP=Professional Paper; Bull=Bulletin; WS=Water-Supply and Irrigation Paper; GF=Geologic Folio; N and N=Cape Nome and Norton Bay pamphlet, and Copper=Copper River pamphlet, both catalogued on page 33 of this bulletin; I=part I, II=part II, etc.; p=page, pp=pages.]

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O

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 215.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

The Bulletins, Professional Papers, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports. This bulletin is the twenty-fourth in Series G, the complete list of which follows (all are bulletins thus far):

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7. Mapoteca geologica Americana: A catalogue of geological maps of America (North and South), 1752–1881, in geographic and chronologic order, by Jules Marcou and John Belknap Marcou. 1884. 184 pp.
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215. Catalogue and index of the publications of the United States Geological Survey, 1901 to 1903, by Philip Creveling Warman. 1903. 234 pp.

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

RESULTS

OF

PRIMARY TRIANGULATION AND PRIMARY TRAVERSE

FISCAL YEAR 1902-03

BY

SAMUEL S. GANNETT

WASHINGTON
GOVERNMENT PRINTING OFFICE
1903

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PLATE I. Map showing condition of astronomic location and primary control 15

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., June 1, 1903.

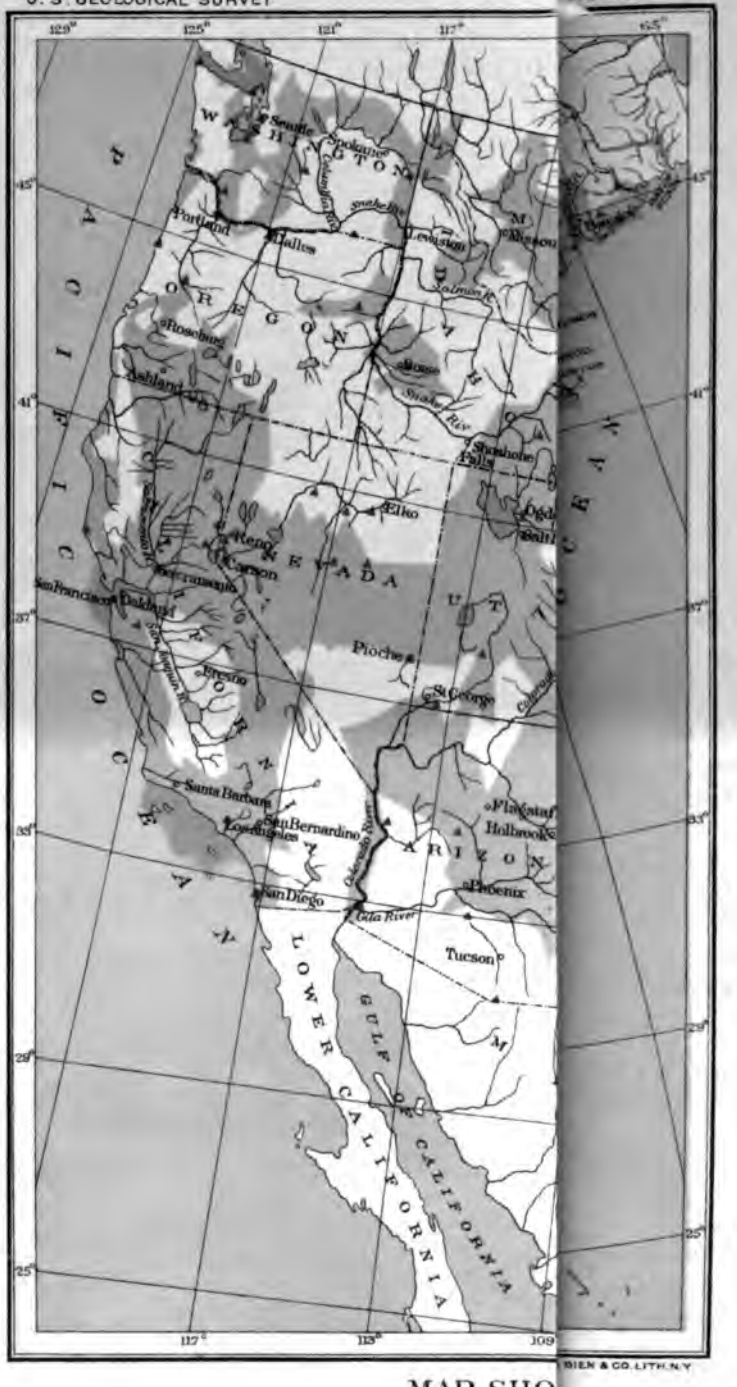
SIR: I have the honor to transmit herewith, in form for publication, the results of the primary triangulation and primary traverse executed by the United States Geological Survey during the fiscal year 1902–3.

The results were computed by Messrs. A. H. Thompson, George T. Hawkins, C. F. Urquhart, H. L. Baldwin, jr., R. H. Chapman, Sledge Tatum, E. L. McNair, J. R. Ellis, L. Scott Smith, and Gilbert Young, under the direction of Mr. S. S. Gannett, who likewise compiled them for publication.

Very respectfully,

R. U. GOODE,
Chairman Topographic Committee.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.



BIEN & CO. LITH. N.Y.

MAP SHO

Areas tinted are controlled by triangulation or traverse

▲ *Astronomic* station

RESULTS OF PRIMARY TRIANGULATION AND PRIMARY TRAVERSE, FISCAL YEAR 1902-3.

By SAMUEL S. GANNETT.

SUMMARY.

Summary of published results, 1902-3: Triangulation, primary traverse, and meridian marks.

Locality.	Triangulation stations.	Traverse stations.	Meridian marks.
ATLANTIC SECTION.			
Maine	23		
New Hampshire	9		
New York	39	112	3
Pennsylvania	5		
West Virginia	69		
Tennessee-Alabama		66	
CENTRAL SECTION.			
Ohio	96	53	
Alabama-Georgia		85	
Kentucky		95	
Mississippi		65	
Illinois		57	
Michigan		34	
Missouri		56	
Kansas		137	
North Dakota-Minnesota		34	
ROCKY MOUNTAIN SECTION.			
Colorado-Wyoming	19		
Arizona	34		
Utah	10		
PACIFIC SECTION.			
California-Arizona	64		
California	10		
Oregon	12		
Washington-Idaho	20		
Total	410	794	3

ATLANTIC SECTION OF TOPOGRAPHY.

H. M. WILSON, *Geographer in charge*

MAINE.

TRIANGULATION STATIONS.

Mr. E. L. McNair, topographer, extended triangulation northward from Sabattus-Blue, United States Coast and Geodetic Survey stations, occupying 19 and locating 6 stations for the control of 11 fifteen-minute quadrangles in the Kennebec Valley. Positions are given on the U. S. standard datum.

SABATTUS, ANDROSCOGGIN COUNTY.

A station of the United States Coast and Geodetic Survey on Sabattus Hill in town of Wales, 4½ miles south of Leeds Junction.

Station mark: A copper bolt sunk in solid rock.

[Latitude 44° 08′ 37.83″. Longitude 70° 04′ 43.74″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Blue	162 10 18.59	341 59 13.88	4.8340499
Moose Hill	173 26 06.70	353 23 49.26	4.5801167
York	189 22 31.33	9 26 54.88	4.7077893
Quaker	216 39 30.16	36 52 13.48	4.6073824

BANNOCK, FRANKLIN COUNTY.

In town of Industry, on well-known hill of that name.

Station mark: A bronze tablet cemented in solid rock about 20 feet south of highest point of rock and 2 or 3 feet lower.

Reference marks: (1) Anchor bolt 8.10 feet distant; true azimuth 34½°. (2) Anchor bolt 8.25 feet distant; true azimuth 129°. (3) Anchor bolt 5.25 feet distant; true azimuth 206°.

[Latitude 44° 44′ 02.70″. Longitude 70° 02′ 24.11″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Moose Hill	14 58 01.34	194 54 05.13	4.4591095
Blue	88 32 15.06	268 19 28.61	4.3797228
New Portland	179 55 44.92	359 55 44.28	4.2057468
Jewett	227 00 01.05	47 10 16.74	4.4184434
Bigelow	275 12 31.98	95 25 43.35	4.3953903
York	341 03 26.83	161 06 13.61	4.2073497

BLUE, FRANKLIN COUNTY.

A station of the United States Coast and Geodetic Survey on well-known mountain in town of Avon.

Station mark: An iron bolt originally standing 4 or 5 inches out of rock, but now broken off to surface of rock. Chisel mark around bolt.

[Latitude 44° 43′ 41.44″. Longitude 70° 20′ 33.16″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
New Portland	234 56 22.30	55 09 09.08	4.4650491
Bannock	268 19 28.61	88 32 15.06	4.3799228
York	296 24 29.69	116 40 01.98	4.5140188
Quaker	305 35 39.96	125 59 33.68	4.7447113
Moose Hill	328 29 22.86	148 38 11.41	4.5027541
Sabattus	341 59 13.88	162 10 18.59	4.6073824

MOOSE HILL, FRANKLIN COUNTY.

A prominent bare hill in town of East Livermore, about 3 miles east of Livermore Falls. Land owned by F. H. Record & Bro.

Station mark: A bronze triangulation tablet cemented in solid rock.

Reference marks: (1) A hole drilled 1 inch deep in large bowlder 38.5 feet distant; true azimuth 292° 43′. (2) A hole drilled 8 inches deep in solid ledge 51.8 feet distant; true azimuth 305° 16′.

[Latitude 44° 29′ 01.78″. Longitude 70° 08′ 00.47″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Blue	148 38 11.41	328 29 22.86	4.5027541
Bannock	194 54 05.13	14 58 01.34	4.4591095
York	225 10 42.76	45 17 25.10	4.2513055
Quaker	280 28 45.10	100 43 48.54	4.4625629
Sabattus	353 23 49.26	173 26 06.70	4.5801167

YORK, FRANKLIN COUNTY.

On a bare hill, about 3 miles south of New Sharon, in New Sharon Township, on land owned by Harry B. York.

Station mark: A bronze triangulation tablet cemented in solid rock.

Reference marks: (1) A hole ½ inch in diameter drilled 1½ inches deep in solid ledge distant 23.65 feet; true azimuth 176° 46′. (2) A hole ½ inch in diameter drilled 2 inches deep in solid ledge distant 27.90 feet; true azimuth 284° 37′.

[Latitude 44° 35′ 48.70″. Longitude 69° 58′ 26.87″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sabattus	9 26 54.88	189 22 31.33	4.7077893
Moose Hill	45 17 25.10	225 10 42.76	4.2513055
Blue	116 40 01.98	296 24 29.69	4.5140188
Bannock	161 06 13.61	341 03 26.83	4.2073497
Bigelow	236 24 05.13	56 34 28.79	4.3700654
Quaker	318 27 37.50	138 35 59.68	4.3781818

QUAKER, KENNEBEC COUNTY.

On Quaker Hill, in town of Sidney, about 6 miles east by road from Belgrade station.

Station mark: An iron ring bolt in solid rock. (Ring above surface.)

[Latitude 44° 26′ 08.81″. Longitude 69° 46′ 30.61″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sabattus	36 52 13.48	216 39 30.16	4.6073824
Moose Hill	100 43 48.54	280 28 45.10	4.4625629
Blue	125 59 33.68	305 35 39.96	4.7447113
York	138 35 59.68	318 27 37.50	4.3781818
Bigelow	186 57 19.39	6 59 19.47	4.4923970

BAKER, PISCATAQUIS COUNTY.

A high, timbered mountain east of Lily Bay, Moosehead Lake. Reached by log roads from Lily Bay House, a 10-mile walk.

Station mark: A bronze triangulation tablet cemented in irregular-shaped bowlder.

[Latitude 45° 34′ 16.28″. Longitude 69° 23′ 39.98″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Squaw	68 50 52.90	248 37 17.0	4.42531
Kineo	118 27 30.00	298 12 58.1	4.47728
Big Spencer	.....	.....	4.34061
Barren	353 55 42.75	173 56 43.0	4.23972

BALD, PISCATAQUIS COUNTY.

(Not occupied.)

A high, bald mountain, about 10 miles west of Blanchard. Can be best reached by going from Forks of Kennebec River over log road (6 miles) to Moxie Pond, thence by boat to Merrills Camp, at Mosquito Narrows. A walk of two and one-fourth hours from Moxie Pond. No trail. Merrills Camp can also be reached by walk of 7 miles over old road from Pleasant Pond.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 45° 15′ 50.46″. Longitude 69° 46′ 20.47″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Moxie			4.06021
Squaw			4.39678
Russell			4.10953

BARREN, PISCATAQUIS COUNTY.

A rough mountain, having a bare, rocky summit, about 4 miles north of Onawa station. Take rowboat to foot of mountain. No trail.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 45° 24′ 56.89″. Longitude 69° 22′ 15.50″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Russell	43 15 11.58	223 04 47.89	4.4459388
Squaw	106 02 42.19	285 48 07.13	4.4432271
Baker	173 56 43.00	353 55 42.75	4.2397200
Guilford	357 34 12.67	177 34 41.57	4.3204474

BIG SPENCER, PISCATAQUIS COUNTY.

(Not occupied.)

Situated on the west end of Big Spencer Mountain, east of Moosehead Lake. Summit timbered. Good view.

Station mark: A hole 1½ inches deep drilled in solid rock.

[Latitude 45° 45′ 41.80.″ Longitude 69° 28′ 01.58″.]

To station—	Azimuth	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Squaw			4.55944
Baker			4.34061

BOARSTONE, PISCATAQUIS COUNTY.

(Not occupied.)

On highest point of a steep, bare, rocky peak, just north of the Canadian Pacific Railway, and about 2 miles from Onawa station.

Station mark: A hole drilled 1 inch deep in solid rock.

[Latitude 45° 22′ 38.60″. Longitude 69° 24′ 15.03″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Russell			4.36273
Guilford			4.23016

GUILFORD, PISCATAQUIS COUNTY.

On rocky point of timbered mountain, about 4 miles north of Guilford. Reached by driving to farm of Charles Howard, then walking from his house.

Station mark: A bronze triangulation tablet cemented in solid rock on highest part of hill.

[Latitude 45° 13′ 40.03″. Longitude 69° 21′ 34.85″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Stickney	39 00 49.07	218 48 20.34	4.5658139
Russell	91 36 31.97	271 25 40.43	4.3016147
Barren	177 34 41.57	357 34 12.67	4.3204474

KINEO, PISCATAQUIS COUNTY.

(Not occupied.)

Situated on the well-known mountain of that name on Moosehead Lake. Highest part of hill is timbered and view is cut off to the north.

Station mark: A bronze tablet cemented in solid rock.

[Latitude 45° 41′ 57.69″. Longitude 69° 43′ 59.47″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Baker	298 12 58	118 27 30	4.47728
Squaw	356 02 48	176 03 42	4.37946

RUSSELL, PISCATAQUIS COUNTY.

A well-known mountain in town of Blanchard, about 4 miles southwest of Blanchard station. Road to Tyler's farm within forty-five minutes' walk of top of mountain.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 45° 13′ 57.22″. Longitude 69° 36′ 52.58″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Stickney	5 58 34.54	185 56 55.86	4.4672024
Foss			4.2631400
Fletcher	50 15 46.48	230 01 53.98	4.5241413
Moxie	82 41 08.14	262 29 13.63	4.3453459
Bald			4.1095300
Squaw	164 46 07.49	344 41 57.87	4.4624148
Barren	223 04 47.89	43 15 11.58	4.4459388
Guilford	271 25 40.43	91 36 31.97	4.3016147

SQUAW, PISCATAQUIS COUNTY.

A well-known mountain about 4 miles west of Greenville Junction. Take boat to Squaw Brook (5 miles) and stop at Hatchery or Shaw's lumber camp, thence by log roads to near top of mountain.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 45° 29′ 03.48″. Longitude 69° 42′ 43.41″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bald			4.3967800
Moxie	24 54 34.00	204 46 47.49	4.5312302
Kineo	176 03 42.00	356 02 47.70	4.3794600
Big Spencer			4.5594400
Baker	248 37 17.00	68 50 52.90	4.4253100
Barren	285 48 07.13	106 02 42.19	4.4432271
Russell	344 41 57.87	164 46 07.49	4.4624148

BIGELOW, SOMERSET COUNTY.

Situated on a prominent and well-known cleared hill 3½ miles south of Skowhegan.

Station mark: An iron bolt in solid ledge of rock.

Reference marks: (1) A hole drilled 2 inches deep in solid rock distant 81½ feet; true azimuth 307° 28′. (2) A hole drilled 2 inches deep in solid rock distant 51½ feet; true azimuth 17° 18′.

[Latitude 44° 42′ 48.06″. Longitude 69° 43′ 39.65″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Quaker	6 59 19.47	186 57 19.39	4.4923970
York	56 34 28.79	236 24 05.13	4.3700654
Bannock	95 25 43.35	275 12 31.98	4.3953903
New Portland	126 42 01.50	306 28 48.48	4.4886529
Jewett	164 43 07.16	344 40 10.34	4.3199458
Stickney	191 37 06.09	11 40 14.80	4.4644220
Fogg	210 14 54.43	30 18 53.15	4.1698850

FLETCHER, SOMERSET COUNTY.

A timbered mountain in town of Concord, about 4 miles west of Bingham.

Station mark: A bronze tablet cemented in bowlder.

Reference marks: (1) A hole drilled 2 inches deep in highest bowlder on mountain, distant 41.18 feet; true azimuth 156° 38′. (2) Stump of spruce tree 22½ feet high, distant 44.6 feet; true azimuth 232° 20′.

[Latitude 45° 02′ 23.26″. Longitude 69° 56′ 27.12″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
New Portland	23 41 05.81	203 36 52.91	4.2912680
Moxie	191 09 52.28	11 11 51.26	4.2770157
Russell	230 01 53.98	50 15 46.48	4.5241413
Foss	258 32 58.00	78 43 44.00	4.3088370
Stickney	288 45 01.11	108 57 13.18	4.3794348
Jewett	324 53 02.64	144 59 07.68	4.2945517

FOGG, SOMERSET COUNTY.

Situated in town of Cornville, on a bare hill about 6 miles northeast on Skowhegan, on land owned by C. M. Fogg.

Station mark: A bronze tablet cemented in solid rock.

[Latitude 44° 49′ 41.74″. Longitude 69° 31′ 00.57″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bigelow	30 18 53.15	210 14 54.43	4.1698850
Jewett	119 43 41.16	299 36 44.97	4.1734321
Stickney	174 20 16.93	354 19 26.58	4.1998577

FOSS, SOMERSET COUNTY.

On a bare rocky mountain, about 2 miles east of Brighton, on land owned by Mr. Foss.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 45° 04′ 33.20″. Longitude 69° 41′ 14.69″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fletcher	78 43 44	258 32 58	4.308837
Moxie			4.339000
Russell			4.263140
Stickney	347 06 01	167 07 28	4.081205

JEWETT, SOMERSET COUNTY.

On a bare hill with lone birch tree, about 10 miles north of Skowhegan, in Madison Township.

Station mark: A bronze tablet cemented in solid rock.

[Latitude 44° 53′ 40.81″. Longitude 69° 47′ 50.57″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bannock	47 10 16.74	227 00 01.05	4.4184434
New Portland	84 46 12.70	264 35 55.59	4.2849545
Fletcher	144 59 07.68	324 53 02.64	4.2945517
Stickney	233 32 44.76	53 38 51.08	4.1501819
Fogg	299 36 44.97	119 43 41.16	4.1734321
Bigelow	344 40 10.34	164 43 07.16	4.3199458

MOXIE, SOMERSET COUNTY.

A well-known mountain, about 15 miles north of Bingham. Can be reached from Pleasant Pond via log roads by walking 8 or 9 miles. Can be reached also by leaving road up Kennebec River at Berrys, about 8 miles above Bingham, and going over Kate Hill.

Station mark: A bronze tablet cemented in solid rock.

Reference mark: A hole drilled 2 inches deep in solid ledge 63.7 feet distant; true azimuth 121° 06′.

[Latitude 45° 12′ 24.64″. Longitude 69° 53′ 39.21″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fletcher	11 11 51.26	191 09 52.28	4.2770157
Squaw	204 46 47.49	24 54 34.00	4.5312302
Bald			4.0602100
Russell	262 29 13.63	82 41 08.14	4.3453459
Foss			4.3390000
Stickney	324 07 20.15	144 17 34.38	4.5109590

NEW PORTLAND, SOMERSET COUNTY.

In town of New Portland, about 2 miles east of New Portland post-office, on a high, bare hill owned by C. A. McKenny.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 44° 52′ 42.97″. Longitude 70° 02′ 25.02″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Blue	55 09 09.08	234 56 22.30	4.4650491
Fletcher	203 36 52.91	23 41 05.81	4.2912680
Jewett	264 35 55.59	84 46 12.70	4.2849545
Bigelow	306 28 48.48	126 42 01.50	4.4886529
Bannock	359 55 44.28	179 55 44.92	4.2057468

STICKNEY, SOMERSET COUNTY.

Situated in town of Athens, about 3½ miles north of Athens village.

Station mark: A bronze tablet cemented in solid rock.

[Latitude 44° 58′ 12.49″. Longitude 69° 39′ 11.90″.]

To station—	Azimuth.	Back azimuth.	Log distance.
	° ′ ″	° ′ ″	*Meters.*
Bigelow	11 40 14.80	191 37 06.09	4.4644220
Jewett	53 38 51.08	233 32 44.76	4.1501819
Fletcher	108 57 13.18	288 45 01.11	4.3794348
Moxie	144 17 34.38	324 07 20.15	4.5109590
Foss	167 07 28.00	347 06 01.00	4.0812050
Russell	185 56 55.86	5 58 34.54	4.4672024
Guilford	218 48 20.34	39 00 49.07	4.5658139
Fogg	354 19 26.58	174 20 16.93	4.1998577

NEW HAMPSHIRE.

TRIANGULATION STATIONS.

Two fifteen-minute quadrangles in the southern portion of the State, covering portions of Hillsboro and Rockingham counties, were controlled by Mr. George T. Hawkins, who occupied six triangulation stations and located three others by intersections in May, 1903.

This work is based upon the positions of Unkonoonuc and Mason, United States standard datum of the Coast and Geodetic Survey.

FEDERAL, HILLSBORO COUNTY.

In the town of Milford, on the north slope of Federal Hill, 2¼ miles south of village of Milford, on land owned by Mr. Jewett and one-fourth mile east of his residence. The highest part of the hill is about 500 feet south of station and covered with high pine timber. Station located on north slope in order to see other signals.

Station mark: A bronze triangulation tablet cemented in solid ledge of granite.

[Latitude 42° 48′ 21.09″. Longitude 71° 37′ 55.12″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mason	68 18 46.9	248 11 24.9	4.20218
Mount Vernon	163 19 21.9	343 17 51.9	4.01970
Unkonoonuc	190 08 54.6	10 10 40.6	4.30159
Turkey	233 54 48.6	53 59 07.9	4.02994

HUDSON, HILLSBORO COUNTY.

Is in town of Hudson, 4 miles northeast of Nashua, on bald hill (except for growth of pines on west end which prevents sight to Nashua), on land owned by Mr. A. C. Cross, and 200 yards southwest of his residence.

Station mark: A bronze triangulation tablet set in granite ledge.

[Latitude 42° 47′ 07.24″. Longitude 71° 23″ 35.20″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Turkey	128 20 48.6	308 15 23.2	4.14157
Derry	185 34 45.9	5 35 23.7	4.11220

MANCHESTER, HILLSBORO COUNTY.

(Not occupied.)

A stone observatory in a park in northeast part of the city of Manchester.

Station mark: Center of observatory.

[Latitude 43° 00′ 04.3″. Longitude 71° 26′ 21.1″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Unkonoonuc	80 47 50.7	260 41 43.6	4.09187
Derry	335 37 56.2	155 40 27.1	4.08553

MASON, HILLSBORO COUNTY.

A triangulation station of the United States Coast and Geodetic Survey south of Mason village on a hill locally known as "Barrett Hill."

Station mark: A hole drilled in solid rock around which is drilled a triangle.

[Latitude 42° 45′ 09.81″. Longitude 71° 48′ 45.96″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mount Vernon	216 27 34.9	36 33 27.4	4.29670
Federal	248 11 24.9	68 18 46.9	4.20218
Nashua	268 00 51.9	88 14 39.0	4.44278

MOUNT VERNON, HILLSBORO COUNTY.

(Not occupied.)

A flag pole on dome of large summer hotel in town of Mount Vernon and a short distance east of village of same name.

[Latitude 42° 53′ 45.8″. Longitude 71° 40′ 07.4″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mason	36 33 27.4	216 27 34.9	4.29670
Unkonoonuc	214 02 28.9	34 03 58.6	4.06739
Turkey	287 38 37.9	107 43 32.9	4.08779
Federal	343 17 51.9	163 19 21.9	4.01968

NASHUA, HILLSBORO COUNTY.

(Not occupied.)

The highest smokestack in the city of Nashua and about one-fourth mile west from business portions of the city.

Station mark: Center of smokestack.

[Latitude 42° 45′ 39.1″. Longitude 71° 28′ 27.6″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mason	88 14 39.0	268 00 51.90	4.44278
Unkonoonuc	159 19 22.7	339 14 42.6	4.42189

TURKEY, HILLSBORO COUNTY.

On a bald hill 1½ miles west of the village of Merrimack, in town of Merrimack.

Station mark: The small pine signal tree 8 inches in diameter marked "U. S." near base.

[Latitude 42° 51′ 45.50″. Longitude 71° 31′ 33.79″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Federal	53 59 07.93	233 54 48.63	4.02994
Mount Vernon	107 43 32.90	287 38 37.90	4.08779
Unkonoonuc	159 07 43.20	339 05 09.60	4.15668
Derry	250 25 30.20	70 31 33.70	4.10925
Hudson	308 15 23.20	128 20 48.60	4.14157

UNKONOONUC, HILLSBORO COUNTY.

A triangulation station of the United States Coast and Geodetic Survey, in Goffstown, 10 miles west of Manchester, on the easterly summit of Unkonoonuc Mountain.

Station mark: A hole drilled in solid rock.

[Latitude 42° 58′ 59.86″. Longitude 71° 35′ 19.38″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Federal	10 10 40.6	190 08 54.6	4.30159
Mount Vernon	34 03 58.6	214 02 28.9	4.06739
Manchester	260 41 43.6	80 47 50.7	4.09187
Derry	297 46 53.6	117 55 31.1	4.28958
Turkey	339 05 09.6	159 07 43.2	4.15668

DERRY, ROCKINGHAM COUNTY.

In town of Londonderry, 3 miles a little north of west from village of Derry, 270 feet south of schoolhouse No. 8 on northwest of slope of hill. The summit, which is about 400 feet southeast of station, is covered by dense growth of pine.

Station mark: A bronze triangulation tablet cemented in large granite bowlder.

[Latitude 42° 54′ 04.85″. Longitude 71° 22′ 39.72″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hudson	5 35 23.7	185 34 45.9	4.11220
Turkey	70 31 33.7	250 25 30.2	4.10925
Unkonoonuc	117 55 31.1	297 46 53.6	4.28958
Manchester	155 40 27.1	335 37 56.2	4.08553

NEW YORK.

TRIANGULATION STATIONS.

Mr. A. H. Thompson, geographer, extended triangulation westward from the vicinity of Olean nearly to the western border of the State, controlling 4 quadrangles in Cattaraugus and Chautauqua counties and he also located by triangulation 5 stations for the control of 2 quadrangles in Wyoming and Livingston counties.

Mr. Oscar Jones, topographer, controlled by triangulation the Carthage quadrangle in Lewis County by locating 5 stations from the line Elmer-Rock.

Mr. McNair controlled 2 fifteen-minute quadrangles in Genesee County by locating 5 stations from Conesus, Perry, and Scottsville. Positions are given on the U. S. standard datum.

DAVIS, ALLEGANY COUNTY.

Located in the northern part of Centerville Township about 2 miles north of Centerville village on land owned by Milton Davis.

Station mark: A bronze triangulation tablet cemented in solid rock under center of signal.

[Latitude 42° 31′ 02.22″. Longitude 78° 14′ 36.23″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Carpenter	176 40 39.24	356 40 09.55	4.2363363
Felch	227 29 55.55	47 38 39.19	4.3784343
Nunda	258 10 54.79	78 25 47.18	4.4878673

FOSTER, CATTARAUGUS COUNTY.

Situated in the southern part of Mansfield Township, on a high hill about 1½ miles a little east of north from the village of Little Valley, on land owned by A. Forster.

Station mark: A sandstone post 40 by 6 by 6 inches set under center of signal 36 inches in the ground, with bronze triangulation tablet cemented in top of post.

[Latitude 42° 15′ 57.91″. Longitude 78° 47′ 23.60″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Shutt	27 47 17.15	207 45 45.85	3.8248931
Tuy	104 24 10.02	284 18 42.06	4.0618700
McCarty	278 32 59.92	98 37 03.83	3.9246544
Townsend	334 32 40.94	154 36 17.21	4.2356988

LEARN, CATTARAUGUAS COUNTY.

Situated in Ischua Township, 3 miles west of Bennett Creek post-office on land owned by Mr. Learn.

Station mark: A copper bolt sunk in granite post 4 feet long; bolt marked "U. S. G. S. 478 N. Y."

[Latitude 42° 14′ 13.27″. Longitude 78° 25′ 53.77″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Flatiron	2 37 16.90	182 36 45.90	4.3683237
Townsend	61 05 16.40	240 54 26.5	4.4047580
McCarty	95 23 17.70	275 12 54.38	4.3293244
Mullaly	110 05 03.20	289 54 18.15	4.3689371

M'CARTY, CATTARAUGUS COUNTY.

Situated near the north line of Great Valley Township on a high hill 1½ miles a little west of north of Ellicottville village on land owned by Daniel McCarty.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, and having a bronze triangulation tablet cemented in its top.

[Latitude 42° 15′ 17.24″. Longitude 78° 41′ 20.91″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Townsend	3 44 43.06	183 44 15.72	4.1558183
Shutt	67 52 46.09	247 47 11.02	4.0914180
Foster	98 37 03.83	278 32 59.92	3.9246544
Mullaly	173 05 56.29	353 05 34.88	3.7830230
Learn	275 12 54.38	95 23 17.70	4.3293244

MULLALY, CATTARAUGUS COUNTY.

Situated on a high hill about 2½ miles a little west of north from the village of Ellicottville, Ellicottville Township, on land owned by P. Mullaly.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, and having a bronze triangulation tablet cemented in its top.

[Latitude 42° 18′ 32.42″. Longitude 78° 41′ 52.74″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Shutt	45 05 04.96	224 59 51.10	4.1794295
Tuy Hill	84 15 23.73	264 06 06.09	4.2751144
Learn	289 54 18.15	110 05 03.20	4.3689371
McCarty	353 05 34.88	173 05 56.29	3.7830230

PINE HILL, CATTARAUGUS COUNTY.

Situated in lot 36 in Randolph Township, 4 miles south of the village of Randolph, on a high hill known as Pine Hill. Land owned by C. B. Bartlett.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground and having a bronze triangulation tablet cemented in its top.

[Latitude 42° 06′ 17.90″. Longitude 78° 59′ 26.35″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Walrod	96 17 22.90	276 12 20.07	4.0185994
Highland	131 52 02.68	311 45 06.34	4.2811005
Tuy	194 33 14.35	14 35 52.35	4.3313226
Shutt	228 17 48.54	48 24 22.49	4.2560628
Townsend	264 17 50.31	84 29 30.93	4.3823034
Read	295 26 28.45	115 27 19.07	3.2836340

READ, CATTARAUGUS COUNTY.

Situated in the southern part of Randolph Township, in lot 10 of the Holland Company land survey, on a high hill known locally as "Mount Tuy." It is 5 miles south of village of East Randolph on land owned by B. Read.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 42° 05′ 51.14″. Longitude 78° 58′ 40.84″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pine	115 27 19.07	295 26 28.45	3.2836340
Shutt	222 27 45.78	42 33 28.58	4.2399748
Townsend	261 46 44.90	81 57 34.84	4.3520529

SHUTT, CATTARAUGUS COUNTY.

Situated in the eastern part of Napoli Township close to the Napoli and Little Valley Township line and about 4 miles southwest of Little Valley Village, on a high hill owned by John Shutt, known locally as Shutts Hill.

Station mark: A stone post 40 by 6 by 6 inches set under center of signal 36 inches in the ground, in center of top of which is cemented a bronze triangulation tablet.

[Latitude 42° 12′ 46.31″. Longitude 78° 49′ 39.40″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Foster	207 45 45.85	27 47 17.15	3.8248931
Read	42 33 28.58	222 27 45.78	4.2399748
Pine Hill	48 24 22.49	228 17 48.54	4.2560628
Tuy Hill	137 26 37.30	317 22 40.81	4.0760509
Mullaly	224 59 51.10	45 05 04.96	4.1794295
McCarty	247 47 11.02	67 52 46.09	4.0914180
Townsend	312 27 23.39	132 32 30.71	4.1538723

TOWNSEND, CATTARAUGUS COUNTY.

Situated in Salamanca Township on what is locally known as "Townsends Hill," about 3 miles southeast of Salamanca. There is a private road from the village of Salamanca to the station.

Station mark: Iron bench mark post marked "U. S. Geological Survey B. M. 480."

Theodolite elevated 15 feet.

[Latitude 42° 07′ 34.25″. Longitude 78° 42′ 01.62″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Read	81 57 34.84	261 46 44.90	4.3520529
Pine	84 29 30.93	264 17 50.31	4.3823034
Shutt	132 32 30.71	312 27 23.39	4.1538723
Foster	154 36 17.21	334 32 40.94	4.2356988
McCarty	183 44 15.72	3 44 43.06	4.1558183
Learn	240 54 26.50	61 05 16.40	4.4047580

TUY HILL, CATTARAUGUS COUNTY.

Situated in the western part of New Albion Township, about 2 miles west of the village of New Albion, on a high hill known locally as Tuy Hill.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground under center of signal; in center of top of post is cemented a bronze triangulation tablet.

[Latitude 42° 17′ 30.59″. Longitude 78° 55′ 31.11″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Foster	284 18 42.06	104 24 10.02	4.0618700
Mullaly	264 06 06.09	84 15 23.73	4.2751144
Pine	14 35 52.25	194 33 14.35	4.3313326
Walrod	38 49 59.78	218 42 18.39	4.4007680
Highland	67 50 11.25	247 40 35.99	4.3260574
Shutt	317 22 40.81	137 26 37.30	4.0760509

BATES, CHAUTAUQUA COUNTY.

Located in the northwestern part of Harmony Township on a commanding hill owned by George C. Bates, about one-fourth mile from the road between Sherman and Harmony townships.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 42° 08′ 24.02″. Longitude 79° 31′ 24.55″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Clymer	29 53 24.01	209 50 37.21	4.0600192
Dewey	77 07 15.77	257 05 29.53	3.5717872
Caselar	158 49 07.99	338 48 11.00	3.7317280
Haynes	235 16 22.46	55 22 58.15	4.2159901
Highland	253 26 35.25	73 35 06.77	4.4923832
Meas	270 06 18.84	90 18 08.34	4.3853254
Panama	356 56 53.53	176 57 05.88	3.9004001

BUSTI, CHAUTAUQUA COUNTY.

Located in the southeastern corner of Busti Township, about 2 miles a little east of south from the village of Busti, on a commanding ridge on land owned by C. Meredith.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 42° 06′ 32.55″. Longitude 79° 16′ 25.26″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Panama	108 08 36.83	287 58 46.96	4.3286072
Meas	194 05 59.78	14 07 45.77	4.1734905
Highland	201 20 39.98	21 25 02.32	4.4000139
Walrod	227 50 04.10	47 56 24.17	4.2451027

CASELAR, CHAUTAUQUA COUNTY.

Located in the southwestern corner of Chautauqua Township, on land owned by Mr. Caselar.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 42° 11′ 06.96″. Longitude 79° 32′ 49.45″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Dewey	16 03 44.36	196 02 55.06	3.7851533
Haynes	254 18 23.71	74 25 56.60	4.2057444
Bates	338 48 11.00	158 49 07.99	3.7317280

CLYMER, CHAUTAUQUA COUNTY.

(Not occupied.)

About 3 miles northwest of the village of Clymer.

Station mark: A tall oak tree standing alone and in full view from all the surrounding country.

[Latitude 42° 03′ 01.31″. Longitude 79° 35′ 33.37″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Dewey	192 49 38.79	12 50 39.43	3.9712038
Bates	209 50 37.21	29 53 24.01	4.0600192
Panama	251 47 45.19	71 50 43.22	3.8107174

DEWEY, CHAUTAUQUA COUNTY.

Located in Sherman Township, about 2 miles southeast of Sherman village, on land owned by Mr. Dewey.

Station mark: An aluminum bolt buried 16 inches in the ground; surface mark, a large bowlder over bolt.

[Latitude 42° 07′ 57.04″. Longitude 79° 34′ 02.91″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Clymer	12 50 39.43	192 49 38.79	3.9762038
Caselar	196 02 55.06	16 03 44.36	3.7851533
Bates	257 05 29.53	77 07 15.77	3.5717872

HAYNES, CHAUTAUQUA COUNTY.

In the northern part of Ellery Township, about 3 miles north of Ellery Center and one-eighth mile east of road leading from Ellery Center to Stockton. Land owned by Mrs. Eliza Haynes.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground.

[Latitude 42° 13′ 27.20″. Longitude 79° 21′ 35.28″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bates	55 22 58.15	235 16 22.46	4.2159901
Caselar	74 25 56.60	254 18 23.71	4.2057444
Highland	271 43 57.27	91 51 53.50	4.2111548

HIGHLAND, CHAUTAUQUA COUNTY.

Located in the western part of Ellington Township, 3 miles directly west of Ellington village, on Highland farm owned by Morril Hoag. Commands view of whole country except directly north.

Station mark: A stone post 36 by 6 by 6 inches set 36 inches in the ground under center of signal.

[Latitude 42° 13′ 10.66″. Longitude 79° 09′ 46.40″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Busti	21 25 02.32	201 20 39.98	4.4000139
Meas	31 44 22.96	211 41 41.49	4.0211111
Bates	73 35 06.77	253 20 35.25	4.4923832
Haynes	91 51 53.50	271 43 57.27	4.2111548
Tuy	247 40 35.99	67 50 11.25	4.3260574
Pine	311 45 06.34	131 52 02.68	4.2811005
Walrod	341 31 39.63	161 33 32.85	4.0873636

MEAS, CHAUTAUQUA COUNTY.

Located near the center of Ellicott Township on a high ridge about 3 miles north of the city of Jamestown and one-third mile south of the Jamestown and Ross Mills road. Land owned by P. A. Melquist.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in ground and having a bronze triangulation tablet cemented in top.

[Latitude 42° 08′ 21.22″. Longitude 79° 13′ 47.09″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Busti	14 07 45.77	194 05 59.78	4.1734905
Panama	71 53 22.33	251 41 45.66	4.4002458
Bates	90 18 08.34	270 06 18.84	4.3853254
Highlands	211 41 41.49	31 44 22.96	4.0211111
Walrod	285 49 02.01	105 53 36.45	3.9898545

PANAMA, CHAUTAUQUA COUNTY.

In the western part of Harmony Township 2 miles a little south of west from Panama village on land owned by J. Brooker.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 42° 04′ 06.70″. Longitude 79° 31′ 06.14″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Clymer	71 50 43.22	251 47 45.19	3.8107174
Bates	176 57 05.88	356 56 53.53	3.9004001
Meas	251 41 45.66	71 53 22.33	4.4002458
Busti	287 58 46.96	108 08 36.83	4.3286072

WALROD, CHAUTAUQUA COUNTY.

Located near the center of Poland Township on a low, bluff-like hill, south of Conewango Creek and about 2 miles south of Kennedy village on land owned by P. Walrod. View not good to southeast but fine in all other directions.

Station mark: A stone post 40 by 6 by 6 inches set under center of signal 36 inches in ground, having a bronze triangulation tablet cemented in its top.

[Latitude 42° 06′ 54.72″. Longitude 79° 06′ 57.95″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Busti	47 56 24.17	227 50 04.10	4.2451027
Meas	105 53 36.45	285 49 02.01	3.9898545
Highland	161 33 32.85	341 31 39.63	4.0873636
Tuy Hill	218 42 18.39	38 49 59.78	4.4007680
Pine Hill	276 12 20.07	96 17 22.90	4.0185994

LEROY, GENESEE COUNTY.

(Not occupied.)

Station mark: Center of standpipe.

[Latitude 42° 58′ 37.1″. Longitude 77° 59′ 47.5″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Attica			4.40362
Conesus			4.60530
Scottsville			4.37105

CARTHAGE, JEFFERSON COUNTY.

(Not occupied.)

Station mark: Center of water-supply standpipe.

[Latitude 43° 59′ 02.38″. Longitude 75° 36′ 16.95″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Croghan	295 24 55.6	115 33 44.7	4.27491
Rock	318 58 20.2	139 08 21.7	4.47068

M'QUILLEN, JEFFERSON COUNTY.

Station on a bare, rocky hill known as Mount McQuillen, 1 mile northeast of Carthage, on property of Mrs. Anna Harvey, who lives 500 yards west of station. Good view in all directions.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 43° 59′ 49.70″. Longitude 75° 35′ 27.82″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Smith	45 43 45.3	225 40 38.9	3.92225
Mound	296 00 10.3	116 03 55.6	3.90571
Croghan (new station)	300 57 28.2	121 05 43.2	4.26850
Denmark Church	355 22 06.2	175 22 34.3	4.04878

MOUND, JEFFERSON COUNTY.

(Not occupied.)

A well-defined granite mound sometimes known as Mount Tom, 5 miles southeast of Carthage, about one-fourth mile to the north of the Forest City or State road. The Carthage city electric-light pole line passes almost over the mound and near the residence of James Dalton.

Station mark: Center of mound.

[Latitude 43° 57′ 55.26″. Longitude 75° 30′ 03.34″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Smith	80 09 40.3	260 02 48.9	4.12776
McQuillen	116 03 55.6	296 00 10.3	3.90571

SMITH, JEFFERSON COUNTY.

On the east side of an east-and-west timbered ridge 4 miles southwest of Carthage, one-half mile north of outlet of Pleasant Lake. Property of William Smith, who lives one-fourth mile south of station. View cut off from north 70° west around by north to north 45° east.

Station mark: Center of elm tree 12 inches in diameter, about which is piled a mound of stones. Tree in center of field, 300 feet from timber.

[Latitude 43° 56′ 40.52″. Longitude 75° 39′ 56.28″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mound	260 02 48.9	80 09 40.3	4.12776
Croghan	279 33 43.7	99 45 04.7	4.34658
Elmer	335 44 13.5	155 47 08.0	4.13634

CROGHAN, LEWIS COUNTY.

(New station.)

Croghan Church, located by Mr. Sledge Tatum, topographer, in 1900, destroyed by fire.

The new station is on south end of a rocky ridge, 1 mile north of the village of Croghan, west side of Beaver River, on property of Christopher Parquet, who lives one-fourth mile east of station.

Station mark: A bronze triangulation tablet set in solid rock.

[Latitude 43° 54′ 39.80″. Longitude 75° 23′ 34.64″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Elmer	61 49 24.3	241 49 24.3	4.26717
Denmark Church	84 01 45.2	263 53 58.7	4.17885
Smith	99 45 04.7	279 33 43.7	4.34658
Carthage	115 33 44.7	295 24 55.6	4.27491
McQuillen	121 05 43.2	300 57 28.2	4.26850
Rock	350 35 27.7	170 36 40.7	4.15885

DENMARK CHURCH, LEWIS COUNTY.

(Not occupied.)

A large, white, square tower on church in the village of Denmark.

Station mark: Center of tower.

[Latitude 43° 53′ 48.38″. Longitude 75° 34′ 47.34″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
McQuillen	175 22 34.3	355 22 06.2	4.04878
Croghan	263 53 58.7	84 01 45.2	4.17885

ELMER, LEWIS COUNTY.

Seven miles northwest of Lowville, N. Y., in the town of Harrisburg, 1 mile south of Harrisburg post-office, on land owned by E. G. Elmer, who lives 300 yards north of station.

Station mark: A marble post 48 by 8 by 8 inches set 36 inches in the ground, and in the center of top is cemented a bronze triangulation tablet.

[Latitude 43° 49′ 56.12″. Longitude 75° 35′ 44.54″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Smith	155 47 08.0	335 44 13.5	4.13634
Croghan (new station)	241 40 58.5	61 49 24.3	4.26717
Rock	286 14 32.9	106 24 11.0	4.28901

ROCK, LEWIS COUNTY.

On a high, rocky ridge, in Watson Township, 8 miles east of Lowville, on land owned by George Venatti.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 43° 46′ 58.98″. Longitude 75° 21′ 49.26″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gum	32 23 03.2	212 18 07.9	4.25241
Elmer	106 24 11.0	286 14 32.9	4.28901
Carthage	139 08 21.7	318 58 20.2	4.47068
Croghan	170 36 40.7	350 35 27.7	4.15885

CALEDONIA, LIVINGSTON COUNTY.

(Not occupied.)

Station mark: Center of standpipe.

[Latitude 42° 58′ 29.8″. Longitude 77° 51′ 59.9″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Scottsville			4.11607
Conesus			4.52169

CULLEY, LIVINGSTON COUNTY.

About 2 miles northwest of Lakeville, on low knoll with timber on northeast side, on land owned by R. H. Culley. Station is on east and west fence line, 7 feet west of north and south fence line and 30 feet west of center of road.

Station mark: A small round bowlder set 1 foot below surface of ground. In top of bowlder is drilled a hole one-fourth inch deep. Over the bowlder is set a bronze triangulation tablet which is covered with earth and a stone on the surface.

[Latitude 42° 51′ 2.48″. Longitude 77° 44′ 18.18″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Perry			4.42857
Conesus			4.20339

NUNDA, LIVINGSTON COUNTY.

Situated in the town of Nunda on the highest part of what is locally known as East Hill.

Station mark: A bowlder 30 inches in diameter sunk flush with ground. In center of top is cemented a triangulation tablet. Station number, 514.

[Latitude 42° 34′ 24.22″. Longitude 77° 52′ 47.36″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Davis	78 25 47.18	258 10 54.79	4.4878673
Carpenter	109 34 18.32	289 18 54.91	4.5179208
Felch	128 32 12.16	308 26 02.46	4.2013176
Perry	147 23 40.42	327 16 44.05	4.4136080
Ridge	165 22 48.65	345 21 19.84	4.0730232

RETSOF, LIVINGSTON COUNTY.

(Not occupied.)

Station mark: Center of tallest brick chimney at the salt works.

[Latitude 42° 50′ 5.1″. Longitude 77° 53′ 00.0″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Culley			4.07855
Retsof			4.36686

ATTICA, WYOMING COUNTY.

Situated in town of Attica, about 1 mile east of Attica Center on bare hill, on land owned by Charles H. Weber. Date post-office. Outlook good except to north.

Station mark: A triangular sandstone 8 inches thick and about 2 feet on each edge in top of which is cemented a bronze triangulation tablet. The stone is buried 1 foot below surface of ground.

Reference marks: (1) A round bowlder containing about 1 cubic foot at west edge of stone pile. Hole drilled 2 inches deep in top. Distance, 166 feet. True azimuth, 239½°. (2) A hole drilled 1½ inches deep in top of irregular-shaped bowlder embedded in ground. Surface exposed about 30 by 18 by 6 inches. Distance, 167½ feet. True azimuth, 47¼°. (3) A hole drilled 1½ inches deep in bowlder embedded in ground, about 12 by 12 by 4 inches exposed. Distance, 50 feet. True azimuth, 117½°.

[Latitude 42° 48′ 48.83″. Longitude 78° 12′ 45.94″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Cobble	1 58 10.52	181 57 59.70	4.0232432
Leroy			4.40362
Scottsville			4.66248
Conesus			4.68021
Perry	289 42 24.00	109 49 08.00	4.15762

CARPENTER, WYOMING COUNTY.

Located in Weathersfield Township, about 2½ miles northwest of the village of Hermitage, on land owned by B. H. Carpenter on a high, gravelly knoll one-eighth mile south of road leading from Gainesville to North Java.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in ground with bronze triangulation tablet cemented in top.

[Latitude 42° 40′ 19.74″. Longitude 78° 15′ 20.09″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Davis	356 40 09.55	176 40 39.24	4.2363363
Perry	237 27 30.84	57 35 59.21	4.3055437
Felch	273 14 00.52	93 23 14.66	4.2706937
Nunda	289 18 54.91	109 34 18.32	4.5179208

COBBLE, WYOMING COUNTY.

On a high, rocky knoll, locally known as Cobble Knoll, in lot 11, Orangeville Township, 1½ miles southwest of the crossroads known as Orangeville Center.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground; in the top is cemented a bronze triangulation tablet.

[Latitude 42° 43′ 07.18″. Longitude 78° 13′ 01.86″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Perry	247 42 28.64	67 49 23.48	4.1766165
Attica	181 57 59.70	1 58 10.52	4.0232422

FELCH, WYOMING COUNTY.

Located in Castile Township, on land owned by William Felch, about 2 miles northeast of Castile village, on a small rocky knoll about one-eighth mile east of the Castile and Perry road.

Station mark: A bronze triangulation tablet cemented in solid rock under center of signal.

[Latitude 42° 39′ 44.84″. Longitude 78° 01′ 42.47″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Nunda	308 26 02.46	128 32 12.16	4.2013176
Davis	47 38 39.19	227 29 55.55	4.3784343
Carpenter	93 23 14.66	273 14 00.52	4.2706937
Perry	172 34 57.57	352 34 11.18	4.0801722

PERRY, WYOMING COUNTY.

Situated in the town of Perry, 2 miles northwest of Perry Center, on the top of a small hill on the farm of Alfred McWethey. The

geodetic point is near the north line fence dividing the farms of Mr. McWethey and Mr. William Fish.

Station mark: A cut stone post 30 by 6 by 6 inches, set 27 inches in the ground. In center of top is cemented a bronze triangulation tablet.

Station number, 513.

[Latitude 42° 46′ 11.35″. Longitude 78° 02′ 50.76″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Ridge	313 17 28.44	133 22 56.22	4.1793698
Nunda	327 16 44.05	147 23 40.42	4.4136080
Felch	352 34 11.18	172 34 57.51	4.0801722
Carpenter	57 35 59.21	237 27 30.84	4.3055437
Cobble	67 49 23.48	247 42 28.64	4.1766165
Attica	109 49 08.00	289 42 24.00	4.1576200
Perry Center	305 38 49.38	125 40 26.73	3.6034672

PERRY CENTER CHURCH SPIRE, WYOMING COUNTY.

[Latitude 42° 44′ 55.57″. Longitude 78° 00′ 27.38″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Perry	125 40 26.73	305 38 49.38	3.6034672
Ridge	316 03 45.00	136 07 35.82	4.0472403

MERIDIAN MARKS.

LITTLE VALLEY, CATTARAUGUS COUNTY.

Location of station: In the court-house grounds, near the southwest corner of same.

Station mark: A stone post 48 by 8 by 8 inches set 40 inches in the ground, in the center of top of which is cemented a bronze meridian tablet.

Distant mark: North of station 456 feet, near the northeast corner of grounds a stone post similar to station mark set 40 inches in the ground.

MAYVILLE, CHAUTAUQUA COUNTY.

Location of station: In schoolhouse grounds, near the southwestern line.

Station mark: A stone post 50 by 8 by 8 inches set 40 inches in the ground, 125 feet from street line. In the center of top of post is cemented a bronze meridian tablet.

Distant mark: North of station 369.8 feet a stone post 50 by 8 by 8 inches set 40 inches in the ground, 25 feet from street line. In center of top of post is cemented a bronze meridian tablet.

WARSAW, WYOMING COUNTY.

Location of station: In the western side of the public school grounds.

Station mark: A stone post 48 by 8 by 8 inches set 40 inches in the ground, in the center of top of which is cemented a bronze meridian tablet.

Distant mark: North of station 598.2 feet, a stone post similar to station mark set 40 inches in the ground.

PRIMARY TRAVERSE.

The following geographic positions for control of the Highmarket and Orwell quadrangles were obtained by primary traverse run in 1902 by Mr. Oscar Jones, topographer. The line starts at Gum triangulation station and follows highways westward to Lowrey triangulation station, thence southward via Thomas triangulation station to Florence triangulation station, and finally eastward and northward to the starting point.

Geographic positions along highways between Gum and Lowrey triangulation stations.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Gum triangulation station	43 38 49.5	75 28 56.6
Road to right	43 39 25.0	75 29 08.7
Turin and Martinsburg, township line between	43 39 56.5	75 29 54.0
Crossroads and railroad crossing	43 40 32.5	75 29 44.8
Road right	43 41 23.7	75 28 52.5
Road right	43 41 15.0	75 30 12.0
Schoolhouse, road left at	43 42 32.8	75 29 35.3
Road corners	43 42 32.4	75 30 54.9
Road east and west	43 43 23.3	75 31 10.2
Road forks	43 43 35.4	75 32 22.9
Road east and west	43 44 09.5	75 32 32.6
Road left	43 44 04.3	75 33 55.5
Road left	43 43 59.9	75 35 14.5
Road right	43 43 59.3	75 35 25.7
Widow Williams, opposite residence of	43 43 52.9	75 37 26.3
Highmarket and Montague, town line between	43 43 57.3	75 38 24.8
Road right	43 44 00.1	75 38 39.0
Road crossing	43 43 53.4	75 41 20.3
Creek right	43 43 02.0	75 41 14.1

Geographic positions along highways between Gum and Lowrey triangulation stations—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Branch right	43 42 45.5	75 42 08.6
Salmon River road	43 42 31.6	75 43 58.4
Salmon River, center of bridge	43 41 39.4	75 44 33.5
Creek right	43 40 30.4	75 45 13.2
Montague and Highmarket, town line between	43 39 26.9	75 46 07.1
Oswego and Jefferson, county line between	43 39 21.8	75 46 13.1
Creek right	43 39 17.3	75 46 18.3
Creek left	43 38 57.7	75 46 40.9
Salmon River	43 39 09.9	75 48 51.5
Creek left	43 38 57.1	75 50 14.9
Greenboro post-office, road at	43 38 37.5	75 53 20.8
Sandy Creek, road on left	43 39 11.1	75 53 58.7
Redfield and Boylston, town line between	43 39 11.8	75 53 59.2
Crossroads	43 39 56.5	75 54 40.7
Road left	43 40 56.8	75 55 23.2
Road left, leave State road, run west	43 41 45.9	75 56 03.2
Crossing county line and State road	43 42 00.0	75 56 13.1
Road left	43 41 23.7	75 58 20.2
North Boylston church, road corner at	43 41 01.2	76 00 06.6
Boylston triangulation station, flag on stump	43 40 43.1	76 00 03.8
Lowrey triangulation station (spur line from station 245)	43 41 47.4	75 59 55.9

Geographic positions along highways between Boylston and Thomas triangulation station.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Crossroads	43 40 19.4	75 58 16.4
Crossroads	43 39 36.2	75 57 53.0
Smartville post-office, crossroads at	43 38 28.9	75 57 44.9
Road left	43 37 28.9	75 58 27.2
Road right	43 37 14.5	75 58 25.5
Boylston and Orwell, town line between	43 36 35.3	75 58 21.9
Crossroads	43 36 03.5	75 58 19.6
Road right	43 35 27 7	75 58 17.4
Orwell and Redfield square, junction of roads	43 34 33.7	75 58 10.0
Thomas triangulation station	43 34 36.4	75 58 54.1

Geographic positions along highways between Thomas and Florence triangulation stations.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Schoolhouse, road on left at	43 34 26.8	75 57 45.0
Road forks	43 33 33.0	75 55 08.9
Crossroads	43 33 06.3	75 55 01.6
Creek right	43 33 08.3	75 53 59.4
Orwell and Redfield, town line between	43 33 05.4	75 53 28.1
Creek right	43 32 32.9	75 52 34.9
Schoolhouse, road on left at	43 32 14.6	75 51 28.2
Salmon River, center of bridge	43 32 05.3	75 51 04.4
Road right	43 31 59.8	75 50 50.3
Redfield, crossroads at	43 31 59.0	75 49 18.5
Road right	43 31 54.5	75 49 03.5
Road forks	43 31 43.0	75 48 39.0
Schoolhouse, road right at	43 31 29.8	75 47 51.0
Salmon River, center of bridge	43 31 27.0	75 47 14.4
Oswego and Lewis county line, road to right on	43 31 02.9	75 45 35.4
Road forks	43 31 57.9	75 44 50.8
Road right	43 31 54.4	75 44 03.1
Road forks	43 31 50.2	75 43 05.4
Road right	43 31 12.6	75 43 10.7
Osceola, crossroads at	43 30 00.7	75 43 21.0
Road right	43 29 23.7	75 43 26.5
Road left	43 29 05.4	75 43 28.9
Crossroads	43 28 14.3	75 43 36.2
Lewis and Oneida county line, road to left on	43 27 49.7	75 43 40.2
Creek left	43 27 00.0	75 44 06.8
Road left	43 26 38.6	75 44 15.8
Road forks	43 26 23.2	75 44 54.9
Florence, road forks at	43 26 18.3	75 45 00.7
Road left	43 24 51.7	75 43 26.8
Road left	43 24 15.8	75 43 04.3
Crossroads	43 23 33.0	75 42 26.1
Road forks	43 23 43.8	75 42 04.0
East Florence, road right	43 23 48.4	75 41 21.2
Florence triangulation station	43 23 14.5	75 39 36.3

Geographic positions along highways from Osceola, via Highmarket, to Gum triangulation station.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Road right	43 29 57.7	75 42 38.7
Branch right	43 30 28.8	75 41 45.6
Creek right	43 30 30.8	75 40 46.5
Creek right	43 29 44.7	75 39 31.0
Osceola and Lewis, town line between	43 29 33.3	75 39 19.5
Salmon River right	43 29 21.4	75 39 06.2
Lischers Mill, road right at	43 29 07.8	75 38 18.4
Schoolhouse, forks of road at	43 27 44.4	75 36 12.4
Road forks	43 26 56.8	75 34 57.1
Creamery, forks of road at	43 26 57.3	75 34 49.2
Road forks	43 26 58.0	75 34 27.8
Branch left	43 28 07.2	75 33 45.9
Road forks	43 29 01.1	75 33 21.1
West Leyden, road right to	43 29 19.9	75 33 07.9
Road forks	43 30 54.7	75 31 51.6
Fish Creek, crossroads at	43 31 14.9	75 32 06.7
Road right	43 31 34.2	75 31 36.0
Road left	43 31 59.0	75 31 17.0
Road left	43 32 57.6	75 30 44.7
Barnes Corners, crossroads at	43 33 09.2	75 30 32.0
Road left	43 34 38.2	75 31 21.1
Highmarket post-office, forks of road at	43 35 06.5	75 31 08.1
Creamery, forks of road at	43 35 20.8	75 31 36.3
Road forks	43 36 20.0	75 31 49.4
Branch left	43 37 32.5	75 31 40.3
Road forks	43 38 13.5	75 31 27.9
Road forks	43 37 55.3	75 30 44.6
Gum triangulation station	43 38 49.5	75 28 56.6

PENNSYLVANIA.

TRIANGULATION STATIONS.

Mr. Sledge Tatum, topographer, extended triangulation westward from stations Berries and Little Mahanoy, so as to control 2 fifteen-minute quadragles in Perry, Juniata, and Snyder counties. Five new stations were selected and occupied in September and October, 1902.

MILLERSTOWN, PERRY COUNTY.

A dome-shaped hill, 2 miles north of Millerstown and ¾ mile east of Juniata River. Summit is bald and very stony. A prominent point locally, though not as high as surrounding timbered ridges.

Station mark: A bronze triangulation tablet countersunk in solid rock 1 foot below surface of ground.

[Latitude 40° 34′ 05.1″. Longitude 77° 10′ 00.9″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Beavertown	188 42 24	8 43 34	4.22242
Little Mahanoy	235 23 23	55 36 28	4.53567
Spruce	293 00 34	113 04 59	4.01864
Newport	347 02 41	217 36 06	4.03919

NEWPORT, PERRY COUNTY.

Situated on timbered ridge 2 miles south of Newport. Summit cleared of timber, and a lone oak tree 8 inches in diameter left standing on highest point. Can be reached by following Duncannon road 1½ miles south from Newport to old sawmill site, thence southwest by trail to summit.

Station mark: Center of lone signal tree.

[Latitude 40° 27′ 11.6″. Longitude 77° 07′ 56.4″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Millerstown	167 04 02	347 02 41	4.11684
Spruce	217 36 06	37 39 10	4.03919
Peters	4 54 14	184 53 30	4.26888

PETERS, PERRY COUNTY.

Situated on Peters Mountain, about 4 miles west of Duncannon; about 2 acres cleared of timber and lone pine tree 24 inches in diameter left standing for signal.

Station mark: A copper bolt cemented in solid rock.

Reference mark: The lone signal tree, true azimuth 331° 09′, 4 feet distant.

[Latitude 40° 21′ 52.7″. Longitude 77° 04′ 19.9″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Newport	152 35 57	332 33 37	4.04464
Spruce	184 53 30	4 54 14	4.26888

SPRUCE, PERRY COUNTY.

(Not occupied.)

A tall spruce tree, 30 inches in diameter, on highest point of ridge, 4 miles west of Liverpool. Lower branches of tree removed, leaving tuft in top—a conspicuous object.

Station mark: Center of spruce tree.

[Latitude 40° 31′ 52.6″. Longitude 77° 03′ 12.7″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Newport	37 39 10	217 36 06	4.03919
Millerstown	113 04 59	293 00 34	4.01864
Beavertown	161 04 51	341 01 36	4.33770

BEAVERTOWN, SNYDER COUNTY.

Situated on Black Log Mountain, about 4 miles south-southeast of Beavertown. Can be reached from Beavertown by following road south from Beavertown railway station to John Nepp's house, about 1 mile; take right hand and follow same to old sawmill site, about one-fourth mile; then take left hand, an abandoned log road, used as bridle trail; follow trail about 2½ miles to signal. (Trail leads from Beavertown to Richland.)

Station mark: A sandstone post, 30 by 10 by 10 inches, with copper bolt set in top and post set flush with surface of ground.

Reference mark: A pine tree 12 inches in diameter, sawed off 20 feet above ground and used for tripod. True azimuth of tree 177° 31′, 4 feet distant.

[Latitude 40° 42′ 59.8″. Longitude 77° 08′ 13.2″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Millerstown	8 43 34	188 42 24	4.22242
L. Mahanoy	263 21 40	83 33 36	4.41336
Berries	320 24 59	140 33.00	4.43606
Spruce	341 01 36	161 04 51	4.33770

WEST VIRGINIA.

TRIANGULATION STATIONS.

Positions published herewith result from the field work of Mr. Sledge Tatum in 1901 and 1902 and from that of Mr. S. S. Gannett in 1902. Previous to the latter date positions depended upon Maryland Heights

and Sugar Loaf stations of the United States Coast and Geodetic Survey near Harpers Ferry, W. Va., but during the season of 1902 Mr. Gannett extended a belt of triangulation from Wray-Gebhardt stations in the transcontinental belt of United States Coast and Geodetic Survey near Huntington, W. Va., up the Ohio River, and connected with previous work near Parkersburg. The discrepancy in latitude and longitude was distributed arbitrarily so as not to disturb figure adjustments, and has been applied so as to reduce all positions to the U. S. standard datum as derived from Wray-Gebhardt.

EGYPT, BARBOUR COUNTY.

Situated on a high, flat-topped hill, locally known as Egypt Hill, 1 mile north of Pepper post-office and one-half mile east of Clarksburg, on Philippi pike.

Station mark: A large green oak tree 3 feet in diameter. A dead oak tree stands about 10 feet south.

[Latitude 39° 12′ 27.99″. Longitude 80° 10′ 21.54″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bear	31 15 21.23	211 10 54.77	4.2914810
Mount Clare	91 36 03.45	271 29 58.25	4.1419390
Bald	157 56 02.38	337 53 29.74	4.1867375

UPTON, BARBOUR COUNTY.

Situated in a pasture on a high, dome-shaped hill, 5 miles east of Philippi, on land owned by Alva Upton, 1,000 feet south of his house.

Station mark: A marble post 36 by 6 by 6 inches, set flush with top of ground, in center of top of which a bronze triangulation tablet is cemented.

[Latitude 39° 09′ 27.5″. Longitude 79° 59′ 37.9″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Nelson	188 22 42	8 24 56	4.53803
Laurel	268 54 43	89 01 01	4.15776

BELINGTON, BARBOUR-RANDOLPH COUNTIES.

A high, bald knob on Laurel Ridge on land owned by Henry Moore, 4 miles east of Belington. It can be reached from Belington by following county road to Moore's farm, thence by trail to summit.

Station mark: Center of cairn 7 feet high.

[Latitude 39° 01′ 43.9″. Longitude 79° 52′ 36.4″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Limestone	218 52 15	39 00 07	4.45623
Shaver	261 08 17	81 17 24	4.32481

LAUREL, BARBOUR-TUCKER COUNTIES.

A high knob on Laurel Ridge, about 15 miles east of Philippi and 12 miles west of Parsons, 0.25 mile north of Philippi-Parson road on line between Barbour and Tucker counties. One-half mile from A. S. Phillips's house and store. Land owned by Shaffer estate.

Station mark: An aluminum bolt set in solid rock 2 feet northwest of chestnut signal tree.

[Latitude 39° 09′ 35.7″. Longitude 79° 49′ 39.1″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Upton	89 01 01	268 54 42	4.15776
Nelson	164 40 54	344 36 48	4.54583
Brown	210 43 11	30 49 52	4.47230
Limestone	240 37 54	60 43 55	4.19614
Shaver	304 14 10	124 21 26	4.30300

SINGLETON, BRAXTON COUNTY.

A high timbered hill on land owned by Sam Singleton, about 7 miles southwest of Burnsville and one-half mile west of Singleton's house. Two acres cleared, giving good view in all directions except southeast.

[Latitude 38° 47′ 20.8″. Longitude 80° 42′ 36.4″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sinking Creek	152 28 18.1	332 22 26.4	4.46450
Sugar Loaf	204 57 55.1	25 03 23.1	4.47749

INDEPENDENCE, BROOKS COUNTY.

Situated 2 miles southwest of the village of Independence, Pa., on a grass hill, on land owned by Mr. Gest. There is a small bunch of locust trees on south side of hill, also a short line of locust trees on east side near summit.

Station mark: A cut marble post 40 by 6 by 6 inches sunk 30 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 40° 15′ 06.03″. Longitude 80° 32′ 27.92″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
West Liberty	33 01 42.51	212 59 23.54	3.9704538
Mount Pleasant	58 27 33.56	238 17 59.54	4.3938130
New Alexander	106 07 03.27	286 01 22.01	4.1133566
Cross Creek	232 43 06.69	52 47 51.53	4.1163183
West Middleton	276 28 07.59	96 31 51.88	3.9168898
Claysville	323 06 27.65	143 11 59.18	4.3069361

DAVIS, CABELL COUNTY.

A triangulation station of the United States Coast and Geodetic Survey on the ridge dividing the headwaters of Davis Creek from those of Four Mile Creek.

Station mark: A pottery pyramid buried 3 feet below ground, and over this is placed a pier of concrete 1 foot square rising 10 inches above the surface.

[Latitude 38° 21′ 06.23″. Longitude 82° 21′ 12.31″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Piney	248 11 16.20	68 22 16.65	4.4436451
Pigeon	298 26 01.30	118 36 40.96	4.4556412
Turkey Knob	347 31 21.76	167 33 02.24	4.2618030

GEBHARDT, CABELL COUNTY.

A station in the transcontinental belt of the United States Coast and Geodetic Survey on Union Ridge, 4 miles east of Lesage, on land owned by William Gebhardt. Timber on northern slope of hill cuts off view northword; an unobstructed view can be had in other directions. Lines of sight were cut out toward Wray and Houck.

Station mark: A section of drain tile pipe 24 inches long, 6 inches in diameter, filled with concrete, set 22 inches in the ground.

Reference marks: Drain tile pipes 24 inches long, 4 inches in diameter, filled with concrete, buried 22 inches in the ground. One north, 5.95 feet distant; one south, 6.08 feet; one east, 5.95 feet; one west, 5.92 feet.

[Latitude 38° 31′ 45.66″. Longitude 82° 15′ 11.05″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wray	112 00 33.64	291 52 47.45	4.2904979
Houck	158 15 28.36	338 02 32.74	4.2608573
Kennard	216 28 26.76	36 34 35.94	4.3810159

ARNETT, DODDRIDGE COUNTY.

Situated about 5 miles northeast of West Union and 2 miles north of Smithburg on a cleared dome-shaped hill with scattering fruit trees on top. Land owned by Absalom Arnett.

Station mark: A marble post 48 by 8 by 8 inches set 48 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 18′ 22.76″. Longitude 80° 42′ 15.84″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Grove	19 13 18.05	199 10 51.27	4.2284800
McDougal	59 44 41.10	239 37 37.75	4.2689572
Childers	300 19 29.26	120 25 48.43	4.2213046

GROVE, DODDRIDGE COUNTY.

Situated about 9 miles south of West Union and 1 mile northeast of Grove post-office, on a high, sharp knob cleared of timber, but with scattering scrubby trees on southwest slope.

Station mark: A sandstone post 36 by 8 by 8 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 09′ 44.65″. Longitude 80° 46′ 07.89″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
King	81 18 18.75	261 07 27.08	[a]4.3994097
Pullman	92 41 08.17	272 33 08.60	[a]4.2612224
McDougal	122 13 55.29	302 09 19.26	[a]4.0929776
Arnett	199 10 51.27	19 13 18.05	4.2284800
Childers	249 09 26.47	69 18 11.71	4.3289945
Bailey	281 18 57.96	101 27 35.60	4.3029196
Sugar Loaf	308 38 53.20	128 46 38.97	4.3568815

[a] Values from Beallsville-Galloway, through Ohio triangulation

M'DOUGAL, DODDRIDGE COUNTY.

Situated 4 miles south of toll gate, on a high cleared hill, known locally as McDougal Hill.

Station mark: A sandstone post 36 by 8 by 8 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 13′ 18.68″. Longitude 80° 53′ 24.69″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pullman	53 20 29.86	233 17 06.04	3.9845751
Oak	179 27 43.34	359 27 40.78	4.0139852
Arnett	239 37 37.75	59 44 41.10	4.2689752
Grove	302 09 19.26	122 13 55.29	4.0929776

LOCUST, GILMER COUNTY.

A knob about 7 miles northwest of Burnsville; cleared on summit and partially timbered on west slope; owned by George Amos. Can be reached from Glenville by following Burnsville pike to Stouts Mill; take left-hand road to top of divide 3 miles to Smith's store, and then take right-hand road one-half mile.

Station mark: A copper bolt set in solid rock.

Reference mark: The lone-oak signal tree; true azimuth 81° 13′ 17″; distance, 5.95 feet from station mark.

[Latitude 38° 53′ 42.63″. Longitude 80° 40′ 57.06″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Miller	85 10 45.43	265 02 46.35	4.2662086
Sinking Creek	131 35 17.75	311 28 23.30	4.3263473
Sugar Loaf	213 39 32.72	33 44 01.59	4.2654511

MILLER, GILMER COUNTY.

A high, cleared knob, on land owned by George Miller, one-half mile east of Letter Gap post-office. Can be reached from Glenville by taking Letter Gap road 6 miles to George Miller's house, thence by trail one-half mile to summit.

Station mark: A copper bolt cemented in top of sandstone post 36 by 8 by 8 inches set flush with surface of ground.

[Latitude 38° 52′ 51.46″. Longitude 80° 53′ 40.08″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pullman			4.5173111
Sinking Creek	189 05 25.88	9 06 31.23	4.1994330
Grove			4.5194893
Locust	265 02 46.35	85 10 45.43	4.2662086
Sugar Loaf	239 12 52.69	59 25 21.32	4.5229039

SINKING CREEK, GILMER COUNTY.

Situated about 10 miles northwest of Glenville at the head of Sinking Creek. Summit cleared on east, west, and south sides with an oak tree left standing for signal.

Station mark: Center of oak signal tree.

[Latitude 39° 01′ 18.46″. Longitude 80° 51′ 56.16″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bailey	247 23 01.61	67 35 17.95	4.4828367
Sugar loaf	266 52 52.65	87 04 16.97	4.4179104
Locust	311 28 23.30	131 35 17.75	4.3263473
Miller	9 06 31.23	189 05 25.88	4.1994330

ALLISON, HANCOCK COUNTY.

Situated 3 miles south of the village of East Liverpool on a cleared hill on land owned by Mr. Allison.

Station mark: A cut marble post 48 by 6 by 6 inches sunk 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 40° 35′ 42.41″. Longitude 80° 34′ 00.49″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Elders	89 54 31.77	269 43 49.10	4.3659427
Hammond	133 48 37.93	313 44 30.76	4.0918031
East Liverpool	172 45 31.96	352 45 16.88	3.6354340
Cow Pasture	209 41 34.97	29 43 00.50	3.7946464

BALD, HARRISON COUNTY.

Situated about 7 miles northeast of Clarksburg and one-half mile south of McAlpin post-office, on a dome-shaped hill in pasture owned by L. A. Righter.

Station mark: A sandstone post 48 by 8 by 8 inches set 48 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 20′ 09.89″. Longitude 80° 14′ 22.72″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bear	8 00 03.12	187 58 08.70	4.4952570
Mount Clare	30 13 00.61	210 09 27.55	4.2053374
Sardis	83 27 02.21	263 19 29.24	4.2364032
Jones	143 07 25.27	323 02 42.79	4.2486797
Rudy	237 58 14.68	58 05 11.02	4.2675001
Egypt	337 53 29.74	157 56 02.38	4.1867375

CHILDERS, HARRISON COUNTY.

Situated on a high cleared hill in pasture about 7 miles south of Salem. Land is owned by P. M. Childers, who lives one-half mile southwest of station.

Station mark: A sandstone post 36 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 13′ 49.79″. Longitude 80° 32′ 16.84″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bailey	1 19 35.49	181 19 28.47	4.0619538
Sugar Loaf	5 50 01.85	185 49 03.44	4.3404851
Grove	69 18 11.71	249 09 26.47	4.3289945
Arnett	120 25 48.43	300 19 29.26	4.2213046
Sardis	221 29 14.05	41 33 01.70	4.1140825
Mount Clare	276 51 15.05	96 59 01.57	4.2511139

MOUNT CLARE, HARRISON COUNTY.

Situated on a sharp peak in a cultivated field one-half mile southeast of Mount Clare post-office and one-fourth mile east of railroad on land owned by Mr. Hazleton.

Station mark: A sandstone post 36 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 12′ 40.16″. Longitude 80° 19′ 59.25″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sugar Loaf	45 30 53.59	225 22 09.65	4.4470601
Bailey	62 30 24.65	242 22 31.63	4.3070570
Childers	96 59 01.57	276 51 15.05	4.2511139
Sardis	142 41 38.09	322 37 38.74	4.1745799
Jones	174 43 03.16	354 41 54.41	4.4496889
Bald	210 09 27.55	30 13 00.61	4.2053374
Egypt	271 29 58.25	91 36 03.45	4.1419390
Bear	347 40 14.46	167 41 52.60	4.2432856

SARDIS, HARRISON COUNTY.

Situated on a high dome-shaped hill about 7 miles northwest of Clarksburg and one-half mile west of Sardis post-office on land owned by William Strother.

Station mark: A marble post 48 by 6 by 6 inches, set 48 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 19′ 05.54″. Longitude 80° 26′ 17.28.″]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Childers	41 33 01.70	221 29 14.05	4.1140825
Jones	201 44 58.89	21 47 50.06	4.2405631
Bald	263 19 29.24	83 27 02.21	4.2364032
Mount Clare	322 37 38.74	142 41 38.09	4.1745779

MELHORN, JACKSON COUNTY.

A bald hill in Grant district 2 miles east of Muses Bottom and 6 miles south of Belleville. Land owned by J. R. Snodgrass, who lives 200 yards northeast of station. An extensive view can be had in all directions, although it is somewhat limited to the southeast.

Station mark: A dressed sandstone post 36 by 8 by 8 inches, set 30 inches in the ground. In the center of top is cemented a bronze triangulation tablet.

[Latitude 39° 03′ 54.96″; [a]39° 03′ 55.01″. Longitude 81° 45′ 12.57″; 81° 45′ 12.70″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Finlay	33 30 24.62	213 23 06.74	4.4833310
Greenler	279 28 14.79	99 41 07.07	4.4750063
Bond	155 53 06.15	335 49 20.01	4.3227202
Lyons	170 55 16.63	350 53 46.66	4.3354363
Wigal	205 43 32.53	25 46 22.69	4.1734691

[a] From Finlay-Greenler.

BAILEY, LEWIS COUNTY.

Situated about 10 miles northwest of Weston and 3½ miles north of Trumansburg on a sharp cleared peak. Land owned by W. G. Bailey.

Station mark: A sandstone post 48 by 12 by 12 inches, set 44 inches in the ground, in top of which is cemented a bronze triangulation tablet.

[Latitude 39° 07′ 35.90″. Longitude 80° 32′ 28.00″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sugar Loaf	10 48 37.94	190 47 46.60	4.0188594
Sinking Creek	67 35 15.00	247 22 59.00	4.4828100
Grove	101 27 35.60	281 18 57.96	4.3029196
Childers	181 19 28.47	1 19 35.49	4.0619538
Mount Clare	242 22 31.63	62 30 24.65	4.3070570
Bear	289 29 08.13	109 38 38.41	4.3629902

SUGAR LOAF, LEWIS COUNTY.

Situated about 10 miles southwest of Weston at head of Murphys Creek. Summit of hill cleared of timber with lone tree left standing for signal.

Station mark: Center of lone signal tree.

[Latitude 39° 02′ 03.24″. Longitude 80° 33′ 49.49″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sinking Creek	87 04 19.00	266 52 55.00	4.4178800
Grove	128 46 38.97	308 38 53.20	4.3568815
Childers	185 49 03.44	5 50 01.85	4.3404851
Bailey	190 47 46.60	10 48 37.94	4.0188594
Mount Clare	225 22 09.65	45 30 53.59	4.4470601
Bear	263 48 44.72	83 59 05.75	4.3773589

PIGEON, LINCOLN COUNTY.

A triangulation station of the United States Coast and Geodetic Survey on the land of Tom Huffman, at the head of Middle Creek, which flows into Mud River.

Station mark: A sandstone post 30 by 6 by 6 inches set 28 inches in the ground. Top of post marked U S + C & G S

[Latitude 38° 13′ 44.05″. Longitude 82° 04′ 00.02″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Table Rock	276 19 40.94	96 36 27.09	4.6002019
Ivy	313 55 13.01	134 16 28.69	4.8474083
Davis	118 36 40.96	298 26 01.30	4.4556412
Turkey Knob	78 49 50.72	258 40 52.54	4.3340906
Porter Knob	52 10 12.35	232 00 04.95	4.4822026
Cove	41 06 29.54	221 00 17.43	4.3488659

ERWIN, MARION COUNTY.

Situated on a high knob about 2½ miles west of Fairmont, on land owned by J. E. Erwin. Knob is cleared of timber with the exception of a few sugar trees standing near summit.

Station mark: A sandstone post 36 by 8 by 8 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 29′ 04.93″. Longitude 80° 11′ 12.53″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jones	81 20 49.47	261 14 05.66	4.1863712
Tennant	171 24 38.61	351 23 39.38	4.1718721
Waters	235 56 08.15	56 02 45.62	4.2550767
Halleck	272 21 54.19	92 30 52.64	4.3066065
Rudy	300 57 57.28	121 02 53.44	4.1139602

JACKSON, MARION COUNTY.

Situated about 7 miles northeast of Mannington and one-half mile northwest of Galletin, on land owned by Mr. Jackson.

Station mark: A sandstone post 36 by 10 by 10 inches set flush with top of ground, in center of top of which a bronze triangulation tablet is cemented.

[Latitude 39° 36′ 43.44″. Longitude 80° 19′ 27.03″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jones	11 32 52.77	191 31 23.18	4.2254500
Evans	64 11 05.70	244 03 54.54	4.2540991
Cornfield	95 35 30.49	275 27 45.01	4.2428447
Littleton	128 49 52.41	308 44 06.94	4.2189038

JONES, MARION COUNTY.

Situated about 6 miles south of Mannington on a high, cleared knob, on land owned by Mr. Jones.

Station mark: A sandstone post 48 by 7 by 7 inches set 48 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

Reference mark: The locust signal tree; distance from station mark, 1.8 feet; true azimuth from same, 197°.

[Latitude 39° 27′ 49.52″. Longitude 80° 21′ 47.56″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sardis	21 47 50.06	201 45 58.89	4.2405631
Tennant	217 13 18.63	37 19 03.77	4.3299984
Erwin	261 14 05.66	81 20 49.47	4.1863712
Rudy	279 19 41.91	99 31 21.55	4.4264067
Bald	323 02 42.79	143 07 25.27	4.2486797
Mount Clare	354 41 54.41	174 43 03.16	4.4496889

RUDY, MARION COUNTY.

Situated on a high, bald hill about 9 miles southeast of Fairmont and 3 miles east of Nuzums Mills.

Station mark: A sandstone post 36 by 8 by 8 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 25′ 27.77″. Longitude 80° 03′ 26.42″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bald	58 05 11.02	237 58 14.68	4.2675001
Jones	99 31 21.55	279 19 41.91	4.4264067
Erwin	121 02 53.44	300 57 57.28	4.1139602
Tennant	148 04 00.55	327 58 04.77	4.4016097
Waters	192 42 44.43	12 44 25.20	4.2350883
Halleck	237 18 53.64	57 22 55.62	4.0340057

RIGGS KNOB, MARSHALL COUNTY.

Situated 6 miles south of the town of Moundsville on the highest point of a cone-shaped hill, locally known as Riggs Knob.

Station mark: A lone locust tree 18 inches in diameter. Center of tree where first limb leaves trunk.

[Latitude 39° 50′ 51.66″. Longitude 80° 45′ 21.94″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Beallsville	89 53 56.89	269 45 19.11	4.2835700
Myers	164 43 47.81	344 41 46.06	4.2327314
Sherrard	199 18 53.15	19 21 27.57	4.2370223
Wilsons Knob	221 59 08.76	42 06 23.22	4.3802408
Rock Lick	263 41 30.14	83 50 12.37	4.2897152

ROCK LICK, MARSHALL COUNTY.

Situated on a bare hill one-half mile south of the town of Rock Lick. A county road passes over north side of hill.

Station mark: A cut marble post 48 by 6 by 6 inches set 36 inches in the ground, in center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 52′ 00.29″. Longitude 80° 31′ 47.16″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Riggs	83 50 12.37	263 41 30.14	4.2897152
Sherrard	136 09 00.37	316 02 51.78	4.2936870
Wilsons Knob	168 13 59.48	348 12 30.92	4.2053434

SHERRARD, MARSHALL COUNTY.

Situated 1 mile west of the village of Sherrard on a small hill in a cleared field on the farm of Mr. Joseph Koty, at the intersection of the Boggs Run and Benwood roads.

Station mark: A cut marble post 48 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 59′ 39.70″. Longitude 80° 41′ 21.36″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Riggs	19 21 27.6	199 18 53.2	4.2370223
Myers	91 09 22.4	271 04 45.8	4.0090858
Centennial	124 04 47.5	304 01 30.3	3.9432300
Mount Pleasant	151 39 31.5	331 35 42.4	4.2492017
Clinton	193 03 24.5	13 04 52.8	4.1578221
Liberty	199 57 09.7	20 00 34.7	4.3437009
West Alexander	230 23 48.2	50 30 02.1	4.2521000
Wilson Knob	261 30 28.4	81 35 08.9	4.0196571
Rock Lick	316 02 51.8	136 09 00.4	4.2936870

WILSON KNOB, MARSHALL COUNTY.

Situated in Sand Hill district on the farm of Mr. G. H. Wilson, near the line fence between the lands of Mr. Wilson and Mr. Howard, where fence crosses summit of hill. The Moundsville and Washington pike passes over north side of hill.

Station mark: A cut marble post 48 by 6 by 6 inches set 40 inches in ground, in center of top of which is cemented a bronze triangulation tablet.

[Latitude 40° 00′ 29.57″. Longitude 80° 34′ 05.11″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Riggs	42 06 23.22	221 59 08.76	4.3802408
Sherrard	81 35 08.88	261 30 28.43	4.0196571
Clinton	150 25 05.10	330 21 55.03	4.1567300
West Alexander	199 13 46.06	19 15 19.31	4.0179782

FINLAY, MASON COUNTY.

A high cleared ridge in Cooper district 13 miles by road east of Point Pleasant; 1½ miles west of Chestnut post-office. Owner of land, David Hart. A fine view can be had in all directions, although there are a few trees 150 yards eastward.

Station mark: A sandstone post 38 by 18 by 18 inches set 36 inches in the ground, top dressed 8 inches square, and has a bronze triangulation tablet cemented in its center.

Reference mark: The chestnut signal tree; azimuth from station mark, 25° 53′; distance, 29 feet.

[Latitude 38° 50′ 11.56″. Longitude 81° 56′ 49.23″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kennard	39 51 27.72	219 46 08.18	4.2842014
Houck	62 53 22.49	242 38 56.49	4.5747505
Graham	105 26 39.74	285 15 10.50	4.4386594
Leonard	128 32 29.47	308 21 37.63	4.5039347
Greenler	157 19 00.37	337 13 28.07	4.5174129
Melhorn	213 23 06.74	33 30 24.62	4.4833310

KENNARD, MASON COUNTY.

On a cultivated hill owned by Charles Kennard, in Clendenning district, 2 miles south of Arlee post-office; 12 miles by road southeast of Gallipolis, Ohio. An unobstructed view can be had in all directions.

Station mark: A sandstone post 36 by 6 inches, set 32 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

Reference marks: Spike driven in top of oak stump 7.9 feet northward. Spike driven in top of oak stump 6.2 feet eastward.

[Latitude 38° 42′ 12.28″. Longitude 82° 05′ 19.52″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gebhardt	36 34 35.94	216 28 26.76	4.3810159
Houck	83 33 45.05	263 24 39.30	4.3270505
Finlay	219 46 08.18	39 51 27.72	4.2842014

HALLECK, MONONGALIA COUNTY.

Situated one-half mile west of Halleck (post-office) in a cultivated field owned by J. Smith.

Station mark: A sandstone post 36 by 10 by 10 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 28′ 36.97″. Longitude 79° 57′ 05.70″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rudy	57 22 55.62	237 18 53.64	4.0340057
Erwin	92 30 52.64	272 21 54.17	4.3066065
Waters	154 05 30.80	334 03 09.26	4.0845244

NELSON, MONONGALIA COUNTY.

About 2 miles south of Halleck post-office, on land owned by the Nelson estate, on a high, flat-topped ridge in pasture.

Station mark: A bronze tablet countersunk in granite post 48 by 8 by 8 inches set flush with top of ground.

[Latitude 39° 27′ 54.7″. Longitude 79° 56′ 07.5″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Upton	8 24 56.0	188 22 42	4.53803
Rock	263 55 08.0	84 02 17	4.21057
Brown	288 52 26.9	109 03 16	4.41227
Laurel	344 36 48.0	164 40 54	4.54583

TENNANT, MONONGALIA COUNTY.

Situated about halfway between Fairview and Center, in a cultivated field, on land owned by Enos Tennant.

Station mark: A granite post 48 by 8 by 8 inches set 48 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 37′ 01.19″. Longitude 80° 12′ 45.59″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jones	37 19 03.77	217 13 18.63	4.3299984
Morley	232 04 10.19	52 11 25.17	4.3132539
Waters	285 03 13.51	105 10 50.82	4.2487846
Rudy	327 58 04.77	148 04 00.55	4.4016097
Erwin	351 23 39.38	171 24 38.61	4.1718721

WYMP, MONONGALIA COUNTY.

On high summit 1 mile southwest of Wymp Gap in Chestnut Ridge, about 9 miles air-line distant northeast of Morgantown, W. Va., and 16 miles south of Uniontown, Pa.

Station mark: A stone post 36 by 12 by 12 inches set flush with surface of ground, in the center of top of which is cemented a copper bolt.

[Latitude 39° 42′ 57.71″. Longitude 79° 45′ 39.08″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Reed	25 47 12.2	205 44 55.7	4.0688994
Waters	54 18 28.5	234 08 48.4	4.4268308
St. Clair	78 48 54.2	258 42 43.2	4.1494319
Morley	94 13 55.6	274 03 51.4	4.3536430
Pondfield	214 23 09.0	34 25 25.3	3.9532404
Mellon	261 57 14.8	82 07 39.3	4.3709214
Kelley	300 28 58.6	120 36 35.7	4.2970427
Piney Swamp	309 23 23.6	129 32 53.4	4.4407570

CLINTON, OHIO COUNTY.

(Secondary station; not occupied.)

A lone tree at intersection of fences on highest point of hill near Clinton post-office.

Station mark: Center of tree.

[Latitude 40° 07′ 13.93″. Longitude 80° 39′ 04.22″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sherrard	13 04 52.8	193 03 24.5	4.1578221
Myers	44 17 53.0	224 11 47.7	4.2850889
Wilsons Knob	330 21 55.0	150 25 05.1	4.1567300

WEST ALEXANDER, OHIO COUNTY.

(Secondary station.)

Situated on a hill 1 mile west of the town of Alexander, Pa.

Station mark: A cut marble post 40 by 6 by 6 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

Reference marks: A maple tree 2 feet in diameter bears N. 85° 56′ W., distant 72.1 feet. A butternut tree 10 inches in diameter bears S. 52° 25′ E., distant 15 feet.

[Latitude 40° 05′ 48.62″. Longitude 80° 31′ 40.14″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wilsons Knob	19 15 19.31	199 13 46.06	4.0179782
Sherrard	50 30 02.08	230 23 48.15	4.2521001

WEST LIBERTY, OHIO COUNTY.

Situated one-half mile north of the village of West Liberty, on the highest point of a bare hill. A county road passes along east side of hill.

Station mark: A cut marble post 48 by 6 by 6 inches set 40 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 40° 10′ 52.03″. Longitude 80° 36′ 03.15″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sherrard	20 00 34.66	199 57 09.72	4.3437009
Mount Pleasant	72 16 23.96	252 09 09.19	4.2241846
New Alexander	147 07 42.89	327 04 20.90	4.1338984
Independence	212 59 23.54	33 01 42.51	3.9704538
West Middleton	242 31 47.76	62 37 50.86	4.1755802
Garrett	259 11 49.03	79 22 34.74	4.3816589
Claysville	295 51 35.55	115 59 25.59	4.2830742

GRIFFITH, PLEASANT COUNTY.

Situated 5 miles southwest of St. Marys on high, dome-shaped hill covered with small peach trees. Land owned by J. H. Griffith.

Station mark: Center of lone oak signal tree.

Reference mark: A sandstone post 48 by 8 by 8 inches set 48 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet. Post is 2 feet northeast of tree.

[Latitude 39° 20′ 46.94″. Longitude 81° 14′ 46.52″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pinnacle	50 10 45.31	230 06 12.40	4.1286309
Pinkerton	110 57 40.75	290 46 50.36	4.4191325
Moore	174 57 55.01	354 57 28.03	4.0637096
Owlshead	247 28 13.79	67 39 14.62	4.4306899
McCullough	273 45 23.40	93 51 52.97	4.1687309

M'CULLOUGH, PLEASANT COUNTY.

Situated 9 miles northwest of Pennsboro on a cleared hill owned by William McCullough, who lives 500 feet west of station.

Station mark: A sandstone post 48 by 8 by 8 inches set 48 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 20′ 15.14″. Longitude 81° 04′ 32.03″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Freeman	12 12 49.86	192 11 22.94	4.1924485
Derrick	43 11 37.96	223 08 10.76	4.0591267
Griffith	93 51 52.97	273 45 23.40	4.1687309
Moore	128 34 48.44	308 27 51.47	4.3030833
Owlshead	222 08 51.38	42 13 22.20	4.1820996
Pullman	336 00 43.00	156 04 21.21	4.3088375

BROWN, PRESTON COUNTY.

In a cultivated field owned by "Junior" Brown 7 miles southeast of Kingwood and 2 miles west of Amblersburg, the nearest railroad station. It is 0.25 mile south of Amblersburg and Kingwood road.

Station mark: An aluminum bolt set in solid rock 4.8 feet east of locust signal tree.

[Latitude 39° 23′ 22.5″. Longitude 79° 39′ 05.8″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Limestone	4 49 07	184 48 30	4.25191
Laurel	30 49 52	210 43 11	4.47230
Nelson	109 03 16	288 52 27	4.41227
St. Joseph Church	129 13 43	309 10 02	4.03270
Rock	140 42 17	320 38 38	4.11591
Reed	150 36 31	330 30 05	4.46982

FUNK, PRESTON COUNTY.

(Not occupied.)

A tall dead chestnut tree standing in cluster of small timber surrounded by cultivated land in field owned by Mr. Funk. Can be reached by following county road to top of Laurel Ridge, thence along ridge to Funk's house. Tree is about 0.25 mile south of house.

Station mark: Center of tree.

[Latitude 39° 17′ 57.9″. Longitude 79° 45′ 54.9″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rock	184 17 01	4 17 41	4.30472
Limestone	313 06 39	133 10 18	4.05638

HOWESVILLE, ST. JOSEPH CHURCH SPIRE, PRESTON COUNTY.

Station mark: Center of church spire.

[Latitude 39° 27′ 03.4″. Longitude 79° 44′ 55.1″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rock	181 21 23	1 21 25	3.51703
Brown	309 10 02	129 13 43	4.03270

KELLEY, PRESTON COUNTY.

On a bald knob locally known by that name, about 6 miles south of Brandonville and 8 miles north of Cranesville, W. Va.

Station mark: A copper bolt cemented in a stone post 36 by 12 by 12 inches set flush with surface of ground.

[Latitude 39° 37′ 31.13″. Longitude 79° 33′ 43.03″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wymp	120 36 35.7	300 28 58.6	4.2970427
Pondfield	145 36 58.1	325 31 36.8	4.3261837
Mellon	204 59 31.0	25 02 17.6	4.1674360
Piney Swamp	330 28 17.6	150 30 10.5	3.9334630

LIMESTONE, PRESTON COUNTY.

On high point on Limestone Ridge, 7 miles north of St. George, on land owned by Thomas Fansler. Station is 0.25 mile south of Thomas Fansler's house, 500 feet west of county road.

Station mark: Center of lone maple signal tree.

[Latitude 39° 13′ 45.1″. Longitude 79° 40′ 08.3″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Belington	39 00 07	218 52 15	4.45623
Laurel	60 43 55	240 37 54	4.19614
Funk	133 10 18	313.06 39	4.05638
Rock	166 21 04	346 18 05	4.45809
Brown	184 48 30	4 49 07	4.25191
Shaver	351 22 01	171 23 16	4.28398

PINEY SWAMP, PRESTON COUNTY.

About 1 mile northwest of Cranesville, on Piney Swamp Knob.

Station mark: A stone post 36 by 12 by 12 inches set flush with surface of ground, in center of top of which is cemented a copper bolt.

[Latitude 39° 33′ 29.03″. Longitude 79° 30′ 45.90″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Reed	104 54 36.5	284 42 51.1	4.4365044
Wymp	129 32 53.4	309 23 23.6	4.4407570
Kelley	150 30 10.5	330 28 17.6	3.9334630
Mellon	185 28 53.8	5 29 47.3	4.3198719
Accident	248 16 18.1	68 24 40.0	4.3057954
Roman Nose	305 25 13.3	125 30 37.5	4.1744346

ROCK, PRESTON COUNTY.

Four miles west of Kingwood, 1,000 feet south of Morgantown and Kinkwood pike, on land owned by Frank Barlow.

Station mark: An aluminum bolt set in solid rock 20 feet square and 20 feet high.

Reference mark: The locust signal tree; true azimuth from station mark 42° 09′ 17″, distance 30.5 feet.

[Latitude 39° 28′ 50.1″. Longitude 79° 44′ 51.8″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
St. Joseph Church	1 21 25	181 21 23	3.51703
Nelson	84 02 17	263 55 08	4.21057
Reed	158 14 09	338 11 23	4.22498
Piney Swamp	246 51 45	67 00 43	4.34167
Brown	320 38 38	140 42 17	4.11591
Limestone	346 18 05	166 21 04	4.45809

DERRICK, RITCHIE COUNTY.

(Not occupied.)

Situated 1 mile south of Goose Creek on summit of a high timbered ridge.

Station mark: Center of oil derrick No. 1.

[Latitude 39° 15′ 44.13″. Longitude 81° 09′ 59.19″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
McCullough	223 08 10.76	43 11 37.96	4.0591267
Freeman	326 26 11.96	146 28 12.01	3.9158432

FREEMAN, RITCHIE COUNTY.

Situated 3 miles southeast of Cairo on a high cleared knob, locally known as Freemans Knob. Land owned by Charley Freeman.

Station mark: A sandstone post 36 by 8 by 8 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 12′ 01.48″. Longitude 81° 06′ 49.38″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Derrick	146 28 12.01	326 26 11.96	3.9158432
McCullough	192 11 22.94	12 12 49.86	4.1924485
McDougal	262 53 51.00	83 02 19.71	4.2889691
Pullman	286 15 35.82	106 20 40.48	4.0812502
King	328 01 21.93	148 03 34.04	3.9771616

KING, RITCHIE COUNTY.

(Not occupied.)

Situated about 7 miles south of Harrisville on a dome-shaped hill, locally known as King Knob. The hill is cleared of timber, but has small scattering peach trees near the summit.

Station mark: A standstone post 36 by 8 by 8 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 07′ 40.44″. Longitude 81° 03′ 20.21″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Freeman	148 03 34.04	328 01 21.93	3.9771616
Pullman	234 32 20.22	54 35 12.58	3.9055762
Grove	261 07 27.08	81 18 18.75	4.3994097

PULLMAN, RITCHIE COUNTY.

Situated about 6 miles east of Harrisville and 1½ miles southeast of Pullman post-office on a high, sharp peak, cleared on top, with lone oak tree left for signal.

Station mark: Center of lone oak signal tree.

[Latitude 39° 10′ 11.72″. Longitude 80° 58′ 47.21″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
King	54 35 12.58	234 32 20.22	3.9055762
Freeman	106 20 40.48	286 15 35.82	4.0812502
McCullough	156 04 21.21	336 00 43.00	4.3088375
Owlshead	183 45 05.38	3 45 57.27	4.4762861
Oak	205 21 35.06	25 24 56.52	4.2507363
McDougal	233 17 06.04	53 20 29.86	3.9845751
Grove	272 33 08.60	92 41 08.17	4.2612224

OAK, TYLER COUNTY.

Situated 1 mile northeast of Stanley post-office on a high, cleared hill in a cultivated field owned by J. C. Garner.

Station mark: A lone tree standing on highest point of hill.

[Latitude 39° 18′ 53.55″. Longitude 80° 53′ 28.72″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pullman	25 24 56.52	205 21 35.06	4.2507363
Owlshead	157 41 32.90	337 39 02.83	4.1732622
McDougal	359 27 40.78	179 27 43.34	4.0139852

OWLSHEAD, TYLER COUNTY.

Situated about 3 miles northeast of Wick on a prominent bare hill, locally known as Owls Head.

Station mark: The quadripod signal.

[Latitude 39° 26′ 20.56″. Longitude 80° 57′ 25.24″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
McCullough	42 13 22.20	222 08 51.38	4.1820996
Griffith	67 39 14.62	247 28 13.79	4.4306899
Moore	92 50 53.05	272 39 24.48	4.4140545
Oak	337 39 02.83	157 41 32.90	4.1732622

SHAVER, TUCKER COUNTY.

A high, rocky mountain 2 miles south of Hendricks. Can best be reached by crossing river at Hendricks, thence by trail south about 1 mile, thence up rough, rocky mountain side 1 mile to signal.

Station mark: An aluminum bolt set in solid rock on highest bald summit.

[Latitude 39° 03′ 28.6″. Longitude 79° 38′ 08.3″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Laurel	124 21 26	304 14 10	4.30300
Limestone	171 23 16	351 22 01	4.28398

PORTER KNOB, WAYNE COUNTY.

A very prominent knob of that name about 8 miles east of Dunlow and 3 miles southwest of Kiahsville, on land owned by Harrison Maynard, near Porter Knob schoolhouse. Summit was cleared of timber and signal erected on highest point.

Station mark: A copper bolt cemented in solid rock.

[Latitude 38° 03′ 39.12″. Longitude 82° 20′ 23.42″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Turkey	190 48 40.38	10 49 50.36	4.1674556
Pigeon	232 00 04.95	52 10 12.35	4.4822026
Cove	258 54 59.84	78 58 54.81	3.9760875

TURKEY KNOB, WAYNE COUNTY.

A high, dome-shaped knob about 10 miles east of Wayne courthouse and 2½ miles southeast of Gilkerson, on land owned by Squire Skaggs. Summit timbered, with broad lines of sight cut out to other stations.

Station mark: A copper bolt cemented in top of sandstone post 36 by 8 by 8 inches set flush with top of ground.

[Latitude 38° 11′ 27.56″. Longitude 82° 18′ 30.08″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Davis	167 33 02.24	347 31 21.76	4.2618030
Pigeon	258 40 52.54	78 49 50.72	4.3340906
Cove	332 40 13.67	152 42 58.99	4.1526839
Porter Knob	10 49 50.36	190 48 40.38	4.1674556

COVE ON LINE BETWEEN WAYNE AND LINCOLN COUNTIES.

A high, cleared knob about 1 mile south of Cove Gap on county-line ridge. It can be reached by following county road to top of divide in Cove Gap, thence southeast, by dim road along ridge, about 1 mile to station.

Station mark: A copper bolt cemented in solid rock.

Reference mark: The sassafras signal tree 4 inches in diameter; true azimuth from station mark 196° 12′ 18″; distance 37 feet.

[Latitude 38° 04′ 37,96″. Longitude 82° 14′ 02.35″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Porter Knob	78 58 54.81	258 54 59.84	3.9760875
Turkey	152 42 58.99	332 40 13.67	4.1526839
Pigeon	221 00 17.43	41 06 29.54	4.3488659

CORNFIELD, WETZEL COUNTY.

Situated on a high knob in a cultivated field owned by Christy Brookover, about three-fourths mile northwest of Kodol.

Station mark: Center of lone walnut tree 10 inches in diameter.

[Latitude 39° 37′ 38.07″. Longitude 80° 31′ 36.98″.]

To station—	Azimuth.	Back azimuth.	Log. distance
	° ′ ″	° ′ ″	*Meters.*
Lavelle	89 03 43.00	269 02 10.00	3.5416800
Littleton	207 21 24.11	27 23 24.52	3.9903050
Jackson	275 27 45.01	95 35 30.49	4.2428447
Jones	322 10 03.76	142 16 18.91	4.3610666
Evans	352 23 51.47	172 24 25.37	3.9824199

EVANS, WETZEL COUNTY.

Situated in a pasture on a high dome-shaped hill about 1 mile southwest of Brink, on land owned by E. B. Evans, about one-half mile west of county line.

Station mark: A bronze triangulation tablet countersunk and cemented in a sandstone post 36 by 12 by 12 inches set flush with surface of ground.

[Latitude 39° 32′ 29.41″. Longitude 80° 30′ 43.77″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Cornfield	172 24 25.37	352 23 51.47	3.9824199
Littleton	190 02 57.60	10 04 27.81	4.2668805
Jackson	244 03 54.54	64 11 05.70	4.2540991

LAVELLE, WETZEL COUNTY.

(Not occupied.)

A high, cleared knob about 4 miles west of Kodol on land owned by Anthony Lavelle.

Station mark: A lone tree on summit.

[Latitude 39° 37′ 36.2″. Longitude 80° 34′ 02.9″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Smithfield	0 01 00	180 01 00	4.21193
Cornfield	269 02 10	89 03 43	3.54168
Evans	333 18 35	153 20 42	4.02481

LITTLETON, WETZEL COUNTY.

A high, dome-shaped hill in pasture 2 miles east of Littleton on land owned by Mrs. Meighen.

Station mark: A lone tree 9 inches in diameter, on the summit.

[Latitude 39° 42′ 19.63″. Longitude 80° 28′ 28.34″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Cornfield	27 23 24.52	207 21 24.11	3.9903050
Jackson	308 44 06.94	128 49 52.41	4.2189038

SMITHFIELD, WETZEL COUNTY.

Situated about 2 miles west of Smithfield on cleared knob of land owned by H. E. Edgell. It can be reached by a trail from Smithfield.

Station mark: A bronze triangulation tablet cemented in top of a sandstone post 36 by 8 by 8 inches set flush with surface of ground.

[Latitude 39° 28′ 47.9″. Longitude 80° 34′ 03.2″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lavelle	180 01 00	0 01 00	4.21193
Evans	214 52 35	34 54 42	3.92057

BEAR, UPSHUR COUNTY.

Situated 7 miles north of Buckhannon, on a sharp knob cleared of timber, with a lone oak tree left standing for signal.

Station mark: Center of lone oak signal tree.

[Latitude 39° 03′ 25.41″. Longitude 80° 17′ 23.70″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sugar Loaf	83 59 05.75	263 48 44.72	4.3773589
Bailey	109 38 38.41	289 29 08.13	4.3629902
Mount Clare	167 41 52.60	347 40 14.46	4.2432856
Bald	187 58 08.70	8 00 03.12	4.4952570
Egypt	211 10 54.77	31 15 21.23	4.2914810

GOFF, WOOD COUNTY.

Situated on a high, cleared hill about 4 miles south of Parkersburg and one-half mile west of the Elizabeth pike. Land owned by Nathan Goff.

Station mark: A stone post 42 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 13′ 18.75″. Longitude 81° 33′ 14.81″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wigal	69 50 00.78	249 45 17.54	4.0590737
Nolan	135 04 44.31	314 58 46.74	4.2822068

MOUNT OLIVE CHURCH, WOOD COUNTY.

(Not occupied.)

A prominent church situated on a high ridge near Powers post-office.

Station mark: Center of church spire.

[Latitude 39° 05′ 38.17″. Longitude 81° 38′ 37.84″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Melhorn	71 29 19.8	251 25 11.0	4.0003208
Lyons			4.3483181
Wigal	163 40 18.4	343 38 59.5	4.0284663

PINNACLE, WOOD COUNTY.

Situated on the summit of a high, sharp hill, known locally as "The Pinnacle," about 2 miles northwest of Deerwalk post-office. Land owned by W. E. Whitlatch.

Station mark: A stone post 36 by 6 by 6 inches, set 36 inches in the ground, in center of top of which is cemented a bronze triangulation tablet.

Reference mark: The tall, black-walnut signal tree standing a little below summit on north side of hill. Distance to center of signal tree, 40.85 feet. True azimuth to same, 250° 00′.

[Latitude 39° 16′ 07.50″. Longitude 81° 21′ 57.37″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Goff	72 17 45.09	252 10 36.52	4.2319366
Seffens	112 47 04.89	292 39 17.80	4.2822967
Pinkerton	141 41 14.67	321 34 57.99	4.3601976
Moore	204 43 50.23	24 47 56.51	4.3462483
Griffith	230 06 12.40	50 10 45.31	4.1286309

WIGAL, WOOD COUNTY.

A round, cleared knob, owned by J. F. Wigal, 2 miles southwest of Eli post-office, 12 miles by road southwest of Parkersburg. An extended view can be had in all directions excepting southeast, which is limited to 4 or 5 miles by higher knobs.

Station mark: A marble post 20 by 6 by 6 inches set 16 inches in a bed of concrete. In center of top of post is cemented a bronze triangulation tablet.

[Latitude 39° 11′ 10.43″. Longitude 81° 40′ 42.92″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Melhorn	25 46 22.69	205 43 32.53	4.1734691
Bond	110 58 02.69	290 51 25.79	4.2074866
Lyons	128 49 58.11	308 45 37.51	4.1032825
Nolan	170 56 08.43	350 54 54.61	4.2486674
Goff	249 45 17.54	69 50 00.78	4.0590737

TENNESSEE—ALABAMA.

PRIMARY TRAVERSE.

Between November 15, 1902, and January 15, 1903, 154 miles of primary traverse were run by Mr. E. L. McNair, topographer, for the control of the Mannie sheet, embracing most of Wayne and a portion of Lawrence County. The line begins at Kelleys Landing, on the Tennessee River, a position determined by Mr. George T. Hawkins, topographer, in 1897, and runs south along country roads to the Alabama line; thence east near the State line to Iron City, Tenn., on the Louisville and Nashville Railway; thence north over country roads to Napier. A spur was also run from Iron City to Tuscumbia, Ala., along the Louisville and Nashville Railway; thence east along the Southern Railway to Tanyard triangulation station, near Town Creek.

This control was supplemented in March, 1903, by a line 32 miles in length run by Mr. Sledge Tatum, topographer, from a point near Abner post-office westward through Waynesboro across the quadrangle.

Geographic positions between Kelleys Landing and Iron City, along country roads.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Kelleys Landing, south azimuth mark (Hawkins, 1897)	35 31 50.2	87 58 29.9
Forks of road at creek crossing	35 30 36.8	87 57 41.3
White Oak Creek, southwest corner of Methodist Church on	35 28 12.9	87 57 20.2
Road northeast 0.75 mile north of Beech Creek crossing	35 26 08.8	87 57 35.7
Forks of road, 400 feet southwest of schoolhouse (road right to Glenkirk)	35 24 45.3	87 57 58.2
Clifton, Russ Hotel, corner Main and River streets, flagstaff on tower of	35 23 13.0	87 59 44.0
Clifton, 2.75 miles southeast of, road southwest	35 21 06.3	87 58 22.7
Huttons Branch, road east about three-fourths mile above mouth of	35 17 44.6	87 55 53.2
Forks of road, road southeast to Houston post-office	35 14 26.4	87 55 03.4
Martins Mills post-office, 600 feet southeast of, forks of road	35 12 34.6	87 57 10.9
Pinhook Church, southwest corner of	35 09 08.4	87 56 00.0
Pinhook Church, 2 miles southwest, of four corners, road west to Savannah	35 08 11.8	87 57 26.2
Forks of road	35 04 52.5	87 57 54.5
Stout post-office, 1 mile east of, southeast azimuth mark, a large nail in notched root of oak tree standing near middle of road, 62 feet south of chimney at east end of house	35 01 51.9	87 57 42.8

Geographic positions between Kelleys Landing and Iron City, etc.—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Stout post-office, northwest azimuth mark 297 feet distant, a nail in notched root of oak tree 4½ feet in circumference, which is 66 feet from southeast corner of store	35 01 52.7	87 57 46.2
Forks of road leaving valley of Second Creek	35 02 47.2	87 55 14.0
Forks of road	35 02 36.3	87 51 40.5
Cypress Inn post-office, 2 miles north of northeast corner of Masonic Hall	35 02 09.5	87 49 26.5
Holt's store, road east at	35 02 51.8	87 49 05.3
Forks of road, signboard "Iron City, 13 miles"	35 03 56.6	87 46 37.2
Pleasant Pines M. E. Church, southeast corner of	35 03 46.9	87 43 42.7
Four corners, bed of old railway grade	35 02 15.3	87 40 19.4
Iron City, 1½ miles northwest of, forks of road	35 01 54.7	87 36 22.9

Geographic positions along Mining Branch of Louisville and Nashville Railway from Iron City to Pinkney.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Wayland Spring station	35 03 37.2	87 34 09.9
Milepost 5, road crossing one-fourth mile south of	35 05 39.2	87 32 32.6
West Point station, center of track opposite	35 07 48.6	87 32 09.2
Pinkney Station, road crossing at	35 09 25.6	87 32 39.4

Geographic positions along country roads between Pinkney and Napier.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Forks of road at crossing of Waterloo road and Aarons Branch of Chisholms Creek	35 12 58.1	87 32 02.0
Top of ridge, main road at south end of clearing, 1¼ miles south of Oak Grove schoolhouse	35 14 47.1	87 31 02.7
Oak Grove schoolhouse and church, southeast corner of	35 15 54.0	87 31 09.4
Abner post-office, four corners at	35 18 08.4	87 28 31.5
Forks of road, signboard "Napier, 8 miles"	35 19 19.0	87 28 12.4
Three corners, north side of fenced field	35 22 15.4	87 28 28.4
Napier station	35 26 38.7	87 28 33.9

Geographic positions along Louisville and Nashville Railway between Iron City, Tenn., and Tuscumbia, Ala.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Iron City station, ¼ mile southeast of, southwest azimuth mark 0′ chisel mark on capstone of bank abutments at northwest corner of 3-span truss bridge over Shoal Creek	35 01 14.6	87 34 47.0
Northeast azimuth mark 356.6 feet distant, chisel mark on capstone of bank abutment at northeast corner of same bridge	35 01 17.4	87 34 44.4
Tennessee-Alabama State line	35 00 12.4	87 36 28.3
ALABAMA.		
Pruitton station, northwest corner of station house	34 59 23.7	87 36 46.0
Hines post-office and store, road crossing near	34 56 56.9	87 38 53.9
Road crossing near section houses	34 55 38.0	87 38 52.8
Jacksonburg station, center of track on block of mail crane	34 53 25.8	87 39 50.0
Milepost 4, road crossing 600 feet north of	34 51 28.0	87 40 04.6
Road crossing near section houses	34 49 28.6	87 40 14.2
Florence station	34 48 15.5	87 39 24.8
Tennessee River railway and road bridge, north end of swing span	34 47 09.1	87 40 13.4
Sheffield, 2 miles east of Louisville and Nashville Railway and Alabama Northern Railway crossing	34 45 02.7	87 41 01.8

Geographic positions along Southern Railway from Tuscumbia to Town Creek.

Station.	Latitude.	Longitude.
ALABAMA.		
	° ′ ″	° ′ ″
Tuscumbia, Southern Railway station, ¼ mile east of switch stand at junction of Louisville and Nashville unused track and Southern Railway	34 43 56.1	87 42 03.4
Southern Railway and Alabama Northern Railway crossing	34 43 09.5	87 39 34.1
Milepost 401, road crossing 1,000 feet east of	34 42 39.5	87 36 44.5
Milepost 398, road crossing at	34 42 34.0	87 33 51.6
Leighton station, road crossing at	34 42 07.3	87 31 44.2
Town Creek, west end of iron bridge over	34 41 44.3	87 27 05.8
Town Creek station, road crossing 360 feet west of	34 41 04.6	87 24 21.3
Tanyard triangulation station, U. S. Coast and Geodetic Survey	34 39 11.1	87 23 01.1

Geographic positions along highways from a point 1 mile west of Abner post-office, westerly through Waynesboro.

Station.	Latitude.	Longitude.
TENNESSEE.	° ′ ″	° ′ ″
Road fork	35 18 10.3	87 29 19.0
Crossroads	35 18 48.3	87 32 42.6
Road right (to Mannie)	35 19 23.4	87 35 05.9
Green River, center of	35 20 30.1	87 39 41.2
Road right, old Furnace	35 20 14.0	87 40 42.6
Road right	35 20 06.1	87 42 22.6
Waynesboro, court-house, southeast corner of	35 19 11.2	87 45 49.3
Road right	35 18 01.2	87 50 09.9
Road left	35 17 43.8	87 50 12.4
Road right (Leatherwood Church)	35 17 29.1	87 51 17.2
Road left	35 17 05.9	87 50 51.7
Road fork	35 14 21.4	87 53 31.5

CENTRAL SECTION OF TOPOGRAPHY.

J. H. RENSHAWE, *Geographer in charge.*

OHIO.

TRIANGULATION STATIONS.

Positions in eastern Ohio published herewith result from the field work of Messrs. W. T. Griswold in 1900, A. H. Thompson in 1901, and G. T. Hawkins and S. S. Gannett in 1902.

Previous to the latter date positions depended upon Maryland Heights and Sugar Loaf stations of the United States Coast and Geodetic Survey, near Harpers Ferry, W. Va., but during the season of 1902 Mr. Gannett extended a belt of triangulation from Wray-Gebhardt stations in the transcontinental belt of United States Coast and Geodetic Survey near Huntington, W. Va., up the Ohio River and connected with previous work near Parkersburg, W. Va.

The discrepancy in latitude and longitude was distributed arbitrarily so as not to disturb figure adjustments, and has been applied so as to reduce all positions to the U. S. standard datum as derived from Wray-Gebhardt.

BOND, ATHENS COUNTY.

On a flat ridge covered with fruit trees in Carthage Township, 7 miles southeast of Guysville. Station is on eastern edge of summit, about 4 feet lower and 200 feet east of highest point, on land owned by William Bond, who lives 300 yards south.

Station mark: A sandstone post 38 by 9 by 9 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 14′ 17.07″. Longitude 81° 51′ 10.74″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fulton	106 34 55.98	286 28 31.40	4.1818210
White	129 06 44.67	308 58 43.68	4.3696920
Southland	179 06 54.47	359 06 47.89	4.2068403
Nolan	226 08 49.91	46 14 13.62	4.2298152
Lyons	247 00 38.53	67 02 55.00	3.7495497
Wigal	290 51 25.79	110 58 02.69	4.2074866
Melhorn	335 49 20.01	155 53 06.15	4.3227202

FULTON, ATHENS COUNTY.

A bare hogback ridge in Lodi Township, 7 miles southeast of Athens. Land owned by William Fulton.

Station mark: A sandstone post 36 by 12 by 12 inches, dressed 8 inches square on top, set 34 inches in the ground; in the center of top is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 16′ 37.29″. Longitude 82° 01′ 18.47″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Townsend (2)	103 28 43.53	283 25 56.81	3.8121631
White	160 49 23.38	340 47 47.32	4.0432222
Southland	230 29 38.61	50 35 57.22	4.2678598
Bond	286 28 31.40	106 34 55.98	4.1818210

LYONS, ATHENS COUNTY.

A bald hill in Troy Township, 1 mile north of Latrobe post-office (Coolville station). Land owned by Eli Lyons, who lives 200 yards southeast of station. A good view in nearly all directions excepting northward, which is limited to 2 miles.

Station mark: A marble post 30 by 6 by 6 inches set 28 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 15′ 28.16″. Longitude 81° 47′ 35.04″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bond	67 02 55.00	247 00 38.53	3.7495497
Nolan	216 30 09.55	36 33 16.71	4.0753794
Wigal	308 45 37.51	128 49 58.11	4.1032825
Melhorn	350 53 46.66	170 55 16.63	4.3354363

NEBO, ATHENS COUNTY.

A small knob in Dover Township, 6 miles by road north of Athens, owned by the Hibbard heirs. Summit covered with a peach orchard (trees mostly dead). A fine view can be had in all directions excepting eastward. The station was selected and occupied by the United States Coast and Geodetic Survey in 1881.

Station mark: A marble post 30 by 6 by 6 inches set 30 inches in the ground over a square earthen pyramid 5 inches high. Top of post is marked, $\frac{\text{U.}}{\text{C. \&}}\frac{\text{S.}}{\text{G.S.}}$

[Latitude 39° 24′ 29.53″. Longitude 82° 05′ 13.90″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Townsend (2)	2 55 47.28	182 55 29.61	4.1162949
McDaniel	83 24 56.70	263 16 04.46	4.3054151
Brooks	124 00 23.75	303 54 52.42	4.1770814
White	334 05 08.78	154 06 01.99	3.6620298

SOUTHLAND, ATHENS COUNTY.

On a flat cultivated ridge owned by W. A. Wagoner, 2 miles northeast of Broadwell post-office, in eastern central part of the county, one-fourth mile west of the Washington County line.

Station mark: A sandstone post 44 by 8 by 8 inches set 40 inches in the ground, just south of fence about 60 yards east of brick house and on opposite side of road. In center of top of post is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 22′ 59.09″. Longitude 81° 51′ 21.13″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fulton	50 35 57.22	230 29 38.61	4.2678598
White	85 47 06.32	265 39 11.18	4.2546960
Nolan	289 09 05.68	109 14 36.48	4.1212888
Bond	359 06 47.89	179 06 54.47	4.2068403

TOWNSEND (2), ATHENS COUNTY.

In Athens Township, 3 miles by road south of Athens, on a flat cultivated ridge owned by Mary Townsend. Station about 50 yards east of a north and south road and 32 feet west of line fence.

Station mark: A limestone post 30 by 6 by 6 inches set 28 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 17′ 26.25″. Longitude 82° 05′ 41.78″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
McKnight	29 45 53.05	209 42 32.43	4.1858081
Zaleski	81 38 31.23	261 26 53.85	4.4264864
McDaniel	118 57 19.04	298 48 45.11	4.3458525
Nebo	182 55 29.61	2 55 47.28	4.1162949
White	196 40 59.96	16 42 10.77	3.9691971
Fulton	283 25 56.81	103 28 43.53	3.8121631
Greenler	359 42 36.35	179 42 39.02	4.3021055

WHITE, ATHENS COUNTY.

On a small knob 4 miles northeast of Athens, near the corner of Athens, Canaan, Ames, and Dover townships. The station is in Canaan Township, on land owned by D. C. White, 5.5 feet east of the southeast corner of a private cemetery, which occupies the summit of knob.

Station mark: A sandstone post 36 by 14 by 7 inches set 34 inches in ground. In center of top is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 22′ 15.58″. Longitude 82° 03′ 50.06″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Townsend (2)	16 42 10.77	196 40 59.96	3.9691971
McDaniel	94 42 43.35	274 32 58.10	4.3453947
Nebo	154 06 01.99	334 05 08.78	3.6620298
Southland	265 39 11.18	85 47 06.32	4.2546960
Bond	308 58 43.68	129 06 44.67	4.3696920
Fulton	340 47 47.32	160 49 23.38	4.0432222

CENTENNIAL, BELMONT COUNTY.

(Secondary station.)

Situated 2½ miles northwest of the city of Bellaire, on land owned by William Nichol.

Station mark: A lone pine tree on highest point of hill.

[Latitude 40° 02′ 19.01″. Longitude 80° 46′ 27.91″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Myers	31 55 37.0	211 54 17.4	3.7445933
Sherrard	304 01 30.3	124 04 47.5	3.9432353

CLARKS HILL, BELMONT COUNTY.

Situated 1 mile east of Bannock station, south of the Cleveland, Lorain and Wheeling Railway, on the summit of a hill owned by the heirs of Mr. Samuel Clark.

Station mark: A cut marble post 6 by 6 inches on top and extending to 6 by 12 inches at bottom. It is 24 inches long, sunk 25 inches in the ground, and set in cement. In the center of the top is cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 06′ 18.28″. Longitude 80° 57′ 45.02″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gallaway	4 07 10.89	184 06 50.55	4.0183310
Cadiz	170 13 03.93	350 11 27.43	4.3177623
Mount Pleasant	257 20 13.51	77 26 58.01	4.1827579

GALLAWAY, BELMONT COUNTY.

Situated 4 miles southeast of Belmont and 2 miles south of Lewis Mills, on the summit of a bare hill owned by Mr. Galloway.

Station mark: A cut marble post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 00′ 40.94″. Longitude 80° 58′ 16.52″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Beallsville	2 29 55.83	182 29 34.33	4.2612655
Clarks Hill	184 06 50.55	4 07 10.89	4.0183311
Mount Pleasant	228 38 05.78	48 45 10.24	4.3180322
Myers	276 53 33.03	96 59 49.03	4.1453970
Jacobsburg	299 35 16.63	119 38 37.92	3.9318086
Newcastle	32 41 30.82	212 37 30.44	4.2166459
Bryan	60 34 11.06	240 30 53.45	3.9231502

JACOBSBURG, BELMONT COUNTY.

Situated on the top of Mr. Robert C. McKelvey's house. Signal was placed on roof within railing. The center comes at edge of second layer of tin from south railing and in center of cupola east and west.

[Latitude 39° 58′ 24.01″. Longitude 80° 53′ 03.37″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Beallsville	30 28 36.52	210 24 54.13	4.2108474
Gallaway	119 38 37.92	299 35 16.63	3.9318086
Myers	248 31 07.18	68 34 01.77	3.8405264

MOUNT PLEASANT, BELMONT COUNTY.

Situated near Morningview post-office, on the north end of a bare hill on the west side of the Wheeling and Mount Pleasant pike, on land owned by Mr. Goff.

Station mark: A cut marble post 40 by 6 by 6 inches set 30 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 08′ 06.07″. Longitude 80° 47′ 16.28″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Myers	6 32 00.56	186 31 12.65	4.1908702
Gallaway	48 45 10.24	228 38 05.78	4.3180322
St. Clairsville	58 03 07.29	237 58 45.00	4.0555471
Clarks Hill	77 26 58.01	257 20 13.51	4.1827579
Cadiz Court-house	130 39 47.88	210 31 40.34	4.3715300
Cadiz	133 05 59.66	312 57 37.85	4.4004381
Hopedale	165 20 26.93	345 17 50.68	4.3534510
New Alexander	207 17 14.17	27 21 07.51	4.2700856
Independence	238 17 59.54	58 27 33.56	4.3938130
West Liberty	252 09 09.19	72 16 23.96	4.2241846
Sherrard	331 35 42.42	151 39 31.51	4.2492017

MYERS, BELMONT COUNTY.

Situated 4 miles southwest of the city of Bellaire, on a cleared knob on land owned by Mr. P. B. Myers.

Station mark: A cut marble post 48 by 6 by 6 inches set 40 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 59′ 46.16″. Longitude 80° 48′ 31.67″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Beallsville	41 39 03.80	221 32 26.97	4.3447990
Jacobsburg	68 34 01.77	248 31 07.18	3.8405264
Gallaway	96 59 49.03	276 53 33.03	4.1453970
Mount Pleasant	186 31 12.65	6 32 00.56	4.1908702
Centennial	211 54 17.38	31 55 36.99	3.7445900
Clinton	224 11 47.70	44 17 52.97	4.2850900
Sherrard	271 04 45.82	91 09 22.42	4.0090858
Riggs	344 41 46.06	164 43 47.81	4.2327314

BARNESVILLE SCHOOLHOUSE, BELMONT COUNTY.

(Not occupied.)

High school in village of Barnesville, Warren Township.
Station mark: Center of cupola.

[Latitude 39° 59′ 21.42″. Longitude 81° 10′ 45.33″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Steele	80 40 36.44	260 38 36.77	3.6510482
Newcastle	322 02 20.19	142 06 20.66	4.1604334

BRYAN, BELMONT COUNTY.

Situated on a high, partially cleared hill in Goshen Township, about 2 miles north of Hunter post-office and 4 miles a little east of south of Bethesda. Land owned by Mr. Patterson.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

Reference mark: The tall dead signal tree on highest part of hill. Distance from station mark, 6 feet; true azimuth 355° 13′.

[Latitude 39° 58′ 27.33″. Longitude 81° 03′ 23.94″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Newcastle	9 15 31.48	189 14 48.57	3.9944416
Steele	93 39 27.39	273 33 44.12	4.1738583
Gallaway	240 30 53.44	60 34 11.06	3.9231502
Beallsville	335 13 05.87	155 16 01.67	4.1914760

FLUSHING, BELMONT COUNTY.

(Not occupied.)

In village of Flushing, in township of same name.

Station mark: Center of cupola on Dr. Burraclough's house.

[Latitude 40° 08′ 58.90″. Longitude 81° 03′ 50.24″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sewellsville	65 25 32.21	245 19 39.26	4.1542888
Prospect Hill	126 53 21.86	306 47 57.45	4.1720159

NEWCASTLE, BELMONT COUNTY.

Situated on a high, cleared hill in Wayne Township, about one-half mile southeast of the village of Newcastle. Land owned by Benjamin Pitman.

Station mark: A stone post 30 by 6 by 6 inches set 30 inches in the ground on solid rock, in center of top of which is cemented a bronze triangulation tablet, "Ohio."

Reference mark: The tall poplar signal tree; distance from station mark, 8.15 feet; true azimuth 67° 49′.

[Latitude 39° 53′ 11.37″. Longitude 81° 04′ 30.75″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wiedman	61 08 38.37	241 04 21.24	4.0370559
Steele	128 47 53.71	308 41 53.72	4.2323159
Bryan	189 14 48.57	9 15 31.48	3.9944416
Gallaway	212 37 30.44	32 41 30.82	4.2166459
Beallsville	298 18 11.29	118 21 49.78	3.9639688

SEWELLSVILLE, BELMONT COUNTY.

Situated on the summit of a high, sharp hill in the village of Sewellsville, Kirkwood Township. Land owned by J. R. Shepherd.

Station mark: A stone post 40 by 6 by 6 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 05′ 46.19″. Longitude 81° 12′ 57.88″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Steele	5 46 28.38	185 45 53.85	4.1023371
Warehime	43 11 35.43	223 05 20.85	4.3052324
McBride	112 07 52.73	292 03 17.71	4.0377941
Tippecanoe	167 35 37.71	347 33 48.12	4.2714644
Prospect Hill	184 05 36.80	4 06 05.81	4.1729676
Deersville	186 18 29.97	6 19 40.88	4.3730446
Cadiz	219 59 50.71	40 08 03.66	4.4482271

STEELE, BELMONT COUNTY.

Situated on a high, cleared hill in Warren Township, about 3 miles west of Barnesville and a few feet east of the Guernsey County line. Land owned by Isaac Steele.

Station mark: A stone post 36 by 6 by 6 inches set 30 inches in the ground and resting on solid rock. In center of top of post is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 58′ 57.84″. Longitude 81° 13′ 51.50″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Calland	21 39 25.88	201 35 53.45	4.3293954
Tucker	46 59 57.57	226 53 52.54	4.2667725
Warehime	80 21 27.72	260 15 48.06	4.1047692
McBride	152 07 18.16	332 03 18.01	4.2763262
Sewellsville	185 45 53.85	5 46 28.38	4.1023371
Bryan	273 33 44.12	93 40 27.39	4.1738583
Beallsville	305 01 44.45	125 11 13.00	4.4179181
Newcastle	308 41 53.72	128 47 53.71	4.2323159
Wiedman	346 36 44.38	166 38 26.80	4.2146469

ST. CLAIRSVILLE COURT-HOUSE, BELMONT COUNTY.

(Not occupied.)

Station mark: Center of cupola on court-house.

[Latitude 40° 04′ 50.90″. Longitude 80° 54′ 04.27″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mount Pleasant	237 58 45.00	58 03 07.29	4.0555471
Sherrard	297 53 05.27	118 01 16.04	4.3112543

CARROLLTON, CARROLL COUNTY.

Situated 2½ miles east of the town of Carrollton, on the Scroggsfield road, on land owned by Mr. Campbell.

Station mark: A cut marble post 40 by 6 by 6 inches set 30 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 34′ 35.51″. Longitude 81° 01′ 47.82″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kensington	204 06 05.89	24 09 27.05	4.2491471
Elders	262 50 29.70	82 57 51.91	4.2070630
Jefferson	340 45 32.78	160 48 24.64	4.2772402

KENSINGTON, CARROLL COUNTY.

Situated 1 mile south of Kensington on the highest point of a wooded hill. A county road passes over the south side of the hill.

Theodolite elevated 60 feet.

Station mark: A cut marble post 48 by 6 by 6 inches, sunk 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 43′ 20.61″. Longitude 80° 56′ 39.07″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Carrollton	24 09 27.05	204 06 05.89	4.2491471
Hammond	283 34 21.24	103 44 59.61	4.3739205
Elders	328 26 39.02	148 30 40.69	4.2218375

PERRYVILLE, CARROLL COUNTY.

(Not occupied.)

Station mark: Center of church spire.

[Latitude 40° 27′ 54.90″. Longitude 81° 05′ 53.49″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jefferson	294 32 31.88	114 38 03.15	4.1217691
Cadiz	337 39 22.36	157 43 02.21	4.3238587

EAST LIVERPOOL CHAPEL, COLUMBIANA COUNTY.

(Not occupied.)

Memorial Chapel in the cemetery at East Liverpool, Ohio.
Station mark: Cap on monument of soldier.

[Latitude 40° 38′ 15.62″. Longitude 80° 34′ 22.70″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hammond	114 30 16.57	294 26 23.76	3.96492
Allison	353 41 30.73	173 41 45.23	3.67712

HAMMOND, COLUMBIANA COUNTY.

Situated 2 miles east of the village of Glasgow on the highest point of a knob, known locally as Hammonds Knob.

Station mark: A cut marble post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 40′ 19.50″. Longitude 80° 40′ 20.06″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wintersville	9 29 54.97	189 27 36.41	4.4836287
Elders	58 57 24.93	238 50 48.93	4.2224370
Kensington	103 44 59.61	283 34 21.24	4.3739205
Allison	313 44 30.76	133 48 37.93	4.0918031

WIDDER, COSHOCTON COUNTY.

On land owned by Mr. Charles Widder, 2½ miles nearly south of New Comerstown, 50 feet west of north and south road, 1½ miles west of Baptist Church, and 600 feet southwest of White schoolhouse.

Station mark: A sandstone post 36 by 6 by 6 inches set 36 inches in the ground, in center of top of which is countersunk and cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 14′ 09.67″. Longitude 81° 36′ 54.11″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kennedy	32 21 19.42	212 17 49.89	4.1574000
Wasen	184 22 07.82	4 22 43.79	4.2359074
Stone Creek	198 41 15.69	18 43 44.26	4.2281117
Port Washington	226 23 39.00	46 27 45.00	4.0942600
Gilmore	245 08 36.06	65 15 18.37	4.2095562
Booth	283 15 05.76	103 17 39.33	3.7615799
Midway	337 39 01.10	157 42 44.98	4.3353514

BUCK, FAIRFIELD COUNTY.

On the farm of Noah Seifert, 7 miles east-southeast of Lancaster, in the southwest part of section 13, Berne Township, on a small mound in a cleared field 100 feet north of the east and west road which crosses summit of hill. Timber obstructs view to the southwest.

Station mark: A marble post 30 by 6 by 6 inches set 28 inches in the ground, over an earthenware pyramid.

[Latitude 39° 40′ 44.49″. Longitude 82° 30′ 07.18″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Brown	34 23 53.61	214 20 02.08	4.1858328
B. I. S. chimney	68 40 43.74	248 35 57.26	4.0607701
B. I. S. water tower			4.0605764
Pleasant (2)	122 42 18.23	302 38 44.12	3.9771162
Cook	318 30 42.80	138 36 43.24	4.3091667
Schultz	338 54 01.46	158 57 18.49	4.3120770

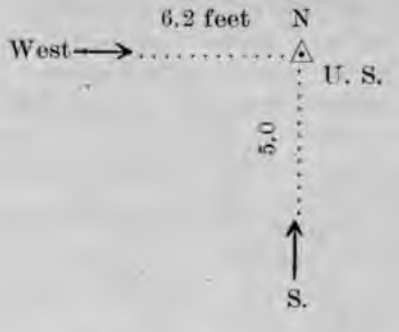
PLEASANT (2), FAIRFIELD COUNTY.

On summit of a bluff, locally called Mount Pleasant, about 300 feet above and 1 mile north of Lancaster, Ohio. Immediately east of fair grounds, on land owned by F. J. Buschemeyer.

Station mark: Center of iron windmill near western end of summit.

Reference mark: A △ cut in sandstone ledge, with arrows cut on edge of bluff pointing to station.

Azimuth from △ to center of windmill, 148° 23′; distance, 228 feet.



[Latitude 39° 43′ 30.56″. Longitude 82° 35′ 42.36″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
B. I. S. chimney	16 17 55.39	196 16 42.49	3.9867933
B. I. S. water tower			3.9820877
Buck	302 38 44.12	122 42 18.23	3.9771162

GRAHAM, GALLIA COUNTY.

A flat, partly timbered ridge 9 miles by road, north-northwest of Gallipolis, 1½ miles east of Evergreen post-office.

View eastward obstructed by timber, but in all other directions an extensive view can be had. Land owned by Charley Graham and rented by Mr. Sparrows.

Station mark: A marble post 30 by 6 by 6 inches, set 28 inches in the ground 7 feet east of signal tree and on south side of rail fence. In center of top is cemented a bronze triangulation tablet, "Ohio."

Reference mark: The oak signal tree on fence line on south side of road, azimuth from mark, 99° 11′; distance, 7 feet.

[Latitude 38° 54′ 07.25″. Longitude 82° 15′ 07.55″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Houck	15 43 53.36	195 40 54.83	4.4049004
Wagner	57 07 05.39	236 58 47.15	4.3584636
Davis	114 12 13.18	294 03 37.74	4.3352839
Leonard	186 38 36.75	6 39 15.03	4.1024633
Finlay	285 15 10.50	105 26 39.74	4.4386594

HOUCK, GALLIA COUNTY.

In Harrison Township, on a bare hill owned by Noah Houck, 3 miles south of Lincoln and one-fourth mile north of Ruby post-office. A few locust trees still standing near summit of hill.

Station mark: A sandstone post 30 by 8 by 8 inches set 28 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

Reference mark: The locust signal tree, true azimuth from mark, 268° 05′; distance, 21.2 feet.

[Latitude 38° 40′ 54.17″. Longitude 82° 19′ 52.51″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wray	49 35 13.43	229 30 22.22	4.1709604
Wagner	134 25 23.87	314 20 05.14	4.2358550
Graham	195 40 54.83	15 43 53.36	4.4049004
Finlay	242 38 56.49	62 53 22.49	4.5747505
Kennard	363 24 39.30	83 33 45.05	4.3270505
Gebhardt	338 02 32.74	158 05 28.36	4.2608573

WAGNER, GALLIA COUNTY.

A bald hill in Greenfield Township, 1½ miles northwest of Cadmus post-office; one-half mile south of the Gallia-Portsmouth pike, at a point 17 miles west of the former, on land owned by Jacob Wagner. A bunch of small locusts on southwest side of hill interferes with view in that direction; in all other directions an extended view can be had.

Station mark: A sandstone post 30 by 15 by 15 inches set 28 inches in the ground; top dressed 9 by 9 inches, having cemented in its center a bronze triangulation tablet, "Ohio."

[Latitude 38° 47′ 24.58″. Longitude 82° 28′ 21.88″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Davis	178 19 50.05	358 19 33.89	4.3278387
Leonard	219 25 58.48	39 34 55.56	4.5104457
Graham	236 58 47.15	57 07 05.39	4.3584636
Houck	314 20 05.14	134 25 23.87	4.2358550
Wray	357 15 02.72	177 15 29.58	4.3360952

CLAYSVILLE, GUERNSEY COUNTY.

On a bald knob one-fourth mile northwest from village of Claysville.

Station mark: A bottle of ashes 2½ feet below surface, above which is a tile 30 by 4 by 4 inches set 30 inches in the ground.

[Latitude 39° 56′ 25.33″. Longitude 81° 40′ 43.04″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sago	131 54 42.28	311 50 42.87	4.0746717
College	193 42 02.84	13 43 15.84	4.0557460
Midway	226 49 26.89	46 55 37.28	4.2725062
Warehime	264 12 48.08	84 24 23.41	4.4121452
Gregg	290 24 08.88	110 31 13.35	4.2245402

COLLEGE, GUERNSEY COUNTY.

In a field about 400 feet southeast from white schoolhouse, on what is known locally as College Hill, 2.5 miles northwest of Cambridge.

Station mark: A limestone post 40 by 7 by 7 inches set 39 inches in the ground, in center of top of which is countersunk and cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 02′ 23.47″. Longitude 81° 38′ 49.47″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Claysville	13 43 15.84	193 42 02.84	4.0557460
Sago	74 54 42.29	254 49 29.58	4.0771353
Kennedy	152 47 17.23	332 45 02.42	4.0350419
Midway	260 51 24.41	80 56 22.09	4.0455896

KENNEDY, GUERNSEY COUNTY.

On east slope of hill, in field owned by Mr. Kennedy, about 5 miles west of Kimbolton and 3 miles northwest of Hopewell village.

Station mark: A sandstone post 40 by 7 by 7 inches set 36 inches in the ground, in center of top of which is countersunk and cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 07′ 36.01″. Longitude 81° 42′ 18.85″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sago	27 14 31.91	207 11 33.69	4.1566993
Widder	212 17 49.89	32 21 19.42	4.1574000
Booth	230 51 07.97	50 57 10.87	4.2342578
Midway	296 16 48.49	116 24 01.27	4.2495411
College	332 45 02.42	152 47 17.23	4.0350419

MIDWAY, GUERNSEY COUNTY.

About 6 miles northeast of Cambridge and 1½ miles southeast of village of Midway, 200 feet west of north and south road and 300 feet northwest of schoolhouse, on a prominent bald hill.

Station mark: A limestone post 36 by 6 by 6 inches set 30 inches in the ground, in center of top of which is countersunk and cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 03′ 20.47″. Longitude 81° 31′ 06.84″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Claysville	46 55 37.28	226 49 26.89	4.2725062
College	80 56 22.09	260 51 24.41	4.0455896
Kennedy	116 24 01.27	296 16 48.49	4.2495411
Widder	157 42 44.98	337 39 01.10	4.3353514
Booth	172 07 03.12	352 05 52.54	4.2759110
Warehime	310 23 54.26	130 29 19.95	4.1983205
Gregg	353 48 09.85	173 49 04.63	4.2735701

HALL'S KNOB, GUERNSEY COUNTY.

(Not occupied.)

A high knob in northern part of Millwood Township, locally known as Joe Hall's knob.

Station mark: Center of tobacco barn on highest part of knob.

[Latitude 39° 59′ 57.14″. Longitude 81° 17′ 15.25″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sewellsville	209 31 02.83	29 33 48.43	4.0925218
Steele	290 41 37.89	110 43 48.80	3.7132089

M'BRIDE, GUERNSEY COUNTY.

Situated on a cleared hill about 2 miles northeast of the village of Antrim, in Londonderry Township. Land owned by J. E. McBride.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 07′ 59.22″. Longitude 81° 20′ 04.72″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Warehime	11 05 17.55	191 03 37.47	4.2832082
Tippecanoe	203 13 59.21	23 16 45.07	4.1873542
Prospect Hill	226 01 54.41	46 06 58.83	4.1902726
Sewellsville	292 03 17.71	112 07 52.73	4.0377941
Steele	332 03 18.01	152 07 18.16	4.2763262

WAREHIME, GUERNSEY COUNTY.

Situated on a high cleared hill in Richland Township, about 2½ miles southeast of Gibson station. Land owned by Albert Warehime.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 57′ 48.36″. Longitude 81° 22′ 40.22″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tucker	5 11 30.20	185 11 04.50	4.0219463
Pleasant	17 43 25.93	197 40 49.35	4.2799538
Gregg	49 56 24.57	229 51 54.19	4.1165523
McBride	191 03 37.47	11 05 17.55	4.2832082
Sewellsville	223 05 20.85	43 11 35.43	4.3052324
Steele	260 15 48.06	80 21 27.72	4,1047692
Wiedman	310 06 46.06	130 14 07.62	4.3304252
Calland	345 08 11.50	165 10 18.15	4.2628296

CADIZ, HARRISON COUNTY.

Situated 1½ miles north of the town of Cadiz on a hill locally known as the sand lot, on land owned by Louis Rider. At forks of road to Hanover and Rumley.

Theodolite elevated 52 feet.

Station mark: A cut marble post 48 by 6 by 6 inches sunk 36 inches in the ground, in center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 17′ 22.36″. Longitude 81° 00′ 14.58″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jefferson	196 06 28.74	16 08 19.68	4.1631951
Hopedale	249 40 19.70	69 46 06.04	4.1295800
Mount Pleasant	312 57 37.85	133 05 59.66	4.4004381
Clarks Hill	350 11 27.43	170 13 03.92	4.3177623
Sewellsville	40 08 03.66	219 59 50.71	4.4482271
Deersville	97 22 22.94	277 15 19.98	4.1923301
Bowerston	124 38 35.25	304 31 25.13	4.2799048

CADIZ COURT-HOUSE, HARRISON COUNTY.

(Not occupied.)

Station mark: Center of cupola on court-house.

[Latitude 40° 16′ 22.39″. Longitude 80° 59′ 52.62″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hopedale	241 40 48.88	61 46 20.94	4.1388232
Mount Pleasant	310 31 40.34	130 39 47.88	4.3715307

JEFFERSON, HARRISON COUNTY.

Situated on a bare hill one-fourth mile northwest of the town of Jefferson, between the forks of the New Philadelphia and Carrollton roads, on land owned by Samuel Meed.

Station mark: A cut marble post 42 by 6 by 6 inches sunk 36 inches in the ground, in center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 24′ 55.88″. Longitude 80° 57′ 23.13″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Cadiz	16 08 19.68	196 06 28.74	4.1631951
Carrollton	160 48 24.64	340 45 32.78	4.2772402
Elders	206 09 16.01	26 13 45.61	4.3452306
Wintersville	274 33 35.99	94 42 21.10	4.2824762
Hopedale	317 18 11.04	137 22 06.82	4.1028039
Deersville	58 24 40.31	238 15 45.68	4.3594835
Bowerston	80 54 37.31	260 45 35.42	4.3003187

BOWERSTON, HARRISON COUNTY.

Situated on a cleared hill in section 25, Monroe Township, about 2 miles south of the village of Bowerston, on land owned by J. E. Brown.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 23′ 13.23″. Longitude 81° 11′ 18.71″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tippecanoe	24 21 54.23	204 19 00.04	4.1880466
Jefferson	260 45 35.42	80 54 37.31	4.3003187
Cadiz	304 31 25.13	124 38 35.25	4.2799048
Deersville	358 23 14.06	178 23 20.87	3.9461666

DEERSVILLE, HARRISON COUNTY.

Situated in the village of Deersville, Franklin Township. Station is the spire or center of cupola of public school building in the eastern part of the village.

Station mark: Center of cupola.

[Latitude 40° 18′ 26.93″. Longitude 81° 11′ 08.13″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sewellsville	6 19 40.88	186 18 29.97	4.3730446
Prospect	10 06 05.78	190 05 23.84	3.9417489
Tippecanoe	51 43 47.10	231 40 46.25	3.9252612
Bowerston	178 23 20.87	358 23 14.06	3.9461666
Jefferson	238 15 45.68	58 24 40.31	4.3594835
Cadiz	277 15 19.98	97 22 22.94	4.1923301

PROSPECT HILL, HARRISON COUNTY.

Situated on the summit of a sharp hill, about 4 miles northeast of Freeport and just east of the Freeport and Cadiz road. The hill is known locally as Prospect Hill and is the highest point for miles around. Land owned by Robert Moore.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 13′ 47.80″. Longitude 81° 12′ 12.96″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sewellsville	4 06 05.81	184 05 36.80	4.1729676
McBride	46 06 58.83	226 01 54.41	4.1902726
Tippecanoe	123 45 44.31	303 43 25.52	3.7857938
Deersville	190 05 23.84	10 06 05.78	3.9417489
Flushing	306 47 57.00	126 53 22.00	4.1720159

RUMLEY, HARRISON COUNTY.

(Not occupied.)

Station mark: Spire of Methodist Episcopal Church.

[Latitude 40° 24′ 14.72″. Longitude 81° 02′ 04.54″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jefferson	259 02 14.82	79 05 17.47	3.8303382
Cadiz	348 24 50.50	168 26 01.90	4.1130606

TIPPECANOE, HARRISON COUNTY.

Situated on the summit of a high, cleared hill in Washington Township, about 2 miles southeast of the village of Tippecanoe. Land owned by William Welch.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 15′ 37.77″. Longitude 81° 15′ 47.79″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
McBride	23 16 45.07	203 13 59.21	4.1873542
Bowerston	204 19 00.04	24 21 54.23	4.1880466
Deersville	231 40 46.25	51 43 47.10	3.9252612
Prospect	303 43 25.52	123 45 44.31	3.7857938
Sewellsville	347 33 48.12	167 35 37.71	4.2714884

BARTON, HOCKING COUNTY.

On a flat cultivated ridge, in section 18, Washington Township, owned by William Barton, who lives one-fourth mile west of station. Selected and occupied by the United States Coast and Geodetic Survey in 1884–85.

Station mark: A marble post 30 by 6 by 6 inches set 28 inches in the ground over an earthenware pyramid. Top of post marked, U. S. / C. & G. S.

Reference marks: Three marble posts 30 by 4 by 4 inches, set as follows:

(1) True azimuth, 99° 53′; distance, 140.25 feet.
(2) True azimuth, 54° 41′; distance, 175.8 feet.
(3) True azimuth, 338° 12′; distance 437.75 feet.

[Latitude 39° 26′ 22.32″. Longitude 82° 29′ 46.50″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Brown	146 40 36.24	326 36 32.15	4.2220318
Schultz	222 46 20.65	42 49 24.02	4.0063768
Cook	228 57 23.90	49 03 10.28	4.2366543
Brooks	257 42 22.62	77 52 27.11	4.3666779
McDaniel	290 56 26.59	111 03 09.10	4.2107237
Zaleski	338 05 36.66	158 09 14.12	4.3433070

BOYS' INDUSTRIAL SCHOOL CHIMNEY, HOCKING COUNTY.

(Not occupied.)

In sections 35 and 36, Hocking Township, 6 miles south of Lancaster. Station mark: Center of tall brick chimney.

[Latitude 39° 38′ 28.64″. Longitude 82° 37′ 36.53″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pleasant (2)	196 16 42.49	16 17 55.39	3.9867933
Buck	248 35 57.26	68 40 43.74	4.0607701
Schultz	309 29 26.62	129 37 29.82	4.3707116
Brown	346 20 02.87	166 20 57.88	3.9405008

BOYS' INDUSTRIAL SCHOOL WATER TOWER, HOCKING COUNTY.

(Not occupied.)

In sections 35 and 36, Hocking Township, 6 miles south of Lancaster. *Station mark:* Center of large white water tower.

[Latitude 39° 38′ 32.48″. Longitude 82° 37′ 38.20″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pleasant (2)			3.9820877
Buck			4.0605764
Schultz	309 39 00.95	129 47 05.22	4.3726735
Brown	346 15 44.39	166 16 40.48	3.9466564

BROOKS, HOCKING COUNTY.

A station of the United States Coast and Geodetic Survey, on a wooded ridge near the northern line of section 19, Ward Township, about 3 miles north of Nelsonville.

Station mark: A marble post 29 by 6 by 6 inches, set 22 inches in the ground, above a square earthenware pyramid 5 inches high. Top of post marked U. S. / C. & G. S.

Reference marks: (1) A marble post 30 by 4 by 4 inches set 28 inches in the ground; azimuth from mark, 74° 11′; distance, 110.75 feet. (2) A marble post 30 by 4 by 4 inches, set 28 inches in the ground; azimuth from mark, 336° 13′; distance, 275 feet. (3) A marble post 30 by 4 by 4 inches, set 28 inches in the ground; azimuth from mark, 200° 35′; distance, 185.4 feet.

[Latitude 39° 29′ 01.86″. Longitude 82° 13′ 55.39″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
McDaniel	35 15 15.27	215 11 53.84	4.1188828
Barton	77 52 27.11	257 42 22.62	4.3666779
Schultz	99 07 21.22	279 00 19.77	4.2050498
Cook	123 23 44.62	303 19 26.03	4.0653816
Nebo	303 54 52.42	124 00 23.75	4.1770814

BROWN, HOCKING COUNTY.

On the property of Isaac Brown, in the southeast quarter of section 30, Good Hope Township, 13 miles by road west of Logan, 13 miles south of Lancaster, 5 miles west of Rockbridge. Station is just east of a cemetery which occupies summit of hill and has a good view in nearly all directions.

Station mark: A marble post 30 by 6 by 6 inches set 28 inches in the ground, over an earthenware pyramid.

[Latitude 39° 33′ 53.90″. Longitude 82° 36′ 10.23″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
B. I. S. water tower	166 16 40.48	346 15 44.39	3.9466564
B. I. S. chimney	166 20 57.88	346 20 02.87	3.9405008
Buck	214 20 02.08	34 23 53.61	4.1858328
Cook	276 38 41.55	96 48 32.74	4.3486753
Schultz	291 55 33.81	112 02 41.69	4.2383235
Barton	326 36 32.15	146 40 36.24	4.2220318

COOK, HOCKING COUNTY.

On the estate of John Cook, in the northeast quarter of section 23, Green Township, 4 miles east of Logan. A good view can be had in all directions excepting north 0° east to north 30° east, which is interfered with by timber at north end of ridge. This station was also occupied by the United States Coast and Geodetic Survey in 1881.

Station mark: A marble post 30 by 6 by 6 inches set 28 inches in the ground, immediately above an earthenware pyramid. Top of post marked

U.	S.
C. &	G. S.

[Latitude 39° 32′ 29.14″. Longitude 82° 20′ 41.83″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Barton	49 03 10.28	228 57 23.90	4.2366543
Schultz	57 44 19.75	237 41 36.70	3.8596674
Brown	96 48 32.74	276 38 41.55	4.3486753
Buck	138 36 43.24	318 30 42.80	4.3091667
Brooks	303 19 26.03	123 23 44.62	4.0653816
McDaniel	352 53 21.32	172 54 18.10	4.2371864

M'DANIEL, HOCKING COUNTY.

Situated in the southern edge of the southwest quarter, section 7, Starr Township, on the estate of George McDaniel, 8 miles southwest of Nelsonville post-office, 15 miles southeast of Logan, and 2 miles east of Starr. The knob is quite prominent and has only a few trees on its southwest side to interfere with view. Selected and occupied by the United States Coast and Geodetic Survey in 1882–83.

Station mark: A marble post 26 by 6 by 6 inches set 25 inches in the ground immediately above a square earthenware pyramid. Top of post marked

U.	S.
C. &	G. S.

[Latitude 39° 23′ 13.57″. Longitude 82° 19′ 12.52″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Zaleski	25 29 15.51	205 26 11.15	4.2098137
Barton	111 03 09.10	290 56 26.59	4.2107237
Schultz	148 07 04.09	328 03 24.55	4.1939372
Cook	172 54 18.10	352 53 21.32	4.2371864
Brooks	215 11 53.84	35 15 15.27	4.1188828
Nebo	263 16 04.46	83 24 56.70	4.3054151
White	274 32 58.10	94 42 43.35	4.3453947
Townsend (2)	298 48 45.11	118 57 19.04	4.3458525

SCHULTZ, HOCKING COUNTY.

A prominent knob 3 miles south of Logan on the estate of Daniel Schultz, in the west half of the northeast quarter of section 26, Falls Township. Summit has apple and peach trees which interfere somewhat with the view. This station was occupied by the United States Coast and Geodetic Survey in 1885.

Station mark: A marble post 30 by 6 by 6 inches set 28 inches in the ground immediately above an earthenware pyramid. Top of post marked U. S. C. & G. S.

[Latitude, 39° 30′ 23.76″. Longitude, 82° 24′ 58.05″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Barton	42 49 24.02	222 46 20.65	4.0033768
Brown	112 02 41.69	291 55 33.81	4.2383235
B. I. S. chimney	129 37 29.82	309 29 26.62	4.3707116
B. I. S. watertower	129 47 05.22	309 39 00.95	4.3726735
Buck	158 57 18.49	338 54 01.46	4.3120770
Cook	237 41 36.70	57 44 19.75	3.8596674
Brooks	279 00 19.77	99 07 21.22	4.2050498
McDaniel	328 03 24.55	148 07 04.09	4.1939372

DAVIS, JACKSON COUNTY.

On a cultivated hill in Bloomfield Township, 12 miles eastward from Jackson, 1½ miles north of Orpheus post-office, 3 miles east of Winchester (Rocky Hill post-office). Land owned by Evan D. Davis who lives about 500 feet west, southwest of station. An unobstructed view can be had for many miles toward the north, northwest, and west, and comparatively few trees obstruct view southwest.

Station mark: Center of wild cherry signal tree about 500 feet east-northeast of Mr. Davis's residence and 13 feet south of an east and west fence.

[Latitude 38° 58′ 54.17″. Longitude 82° 28′ 47.63″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lawler	200 26 28.47	20 28 23.27	4.0984524
Graham	294 03 37.74	114 12 13.18	4.3352839
Wagner	358 19 33.89	178 19 50.05	4.3278387

ELDERS, JEFFERSON COUNTY.

Situated one-half mile south of the village of Monroeville on land owned by Mr. Elder.

Station mark: A cut marble post 48 by 6 by 6 inches set 40 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 35′ 40.04.″ Longitude 80° 50′ 28.10″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jefferson	26 13 45.61	206 09 16.01	4.3452306
Carrollton	82 57 51.91	262 50 29.70	4.2070630
Kensington	148 30 40.69	328 26 39.02	4.2218375
Hammond	238 50 48.93	58 57 24.93	4.2224370
Allison	269 43 49.10	89 54 31.77	4.3659427
Wintersville	336 29 21.40	156 33 37.87	4.3683786

HOPEDALE, JEFFERSON COUNTY.

Situated 2 miles west of Bloomingdale on the north side of the Bloomingdale and Hopedale pike, on the highest point of hill in cleared field belonging to Mr. S. N. Beall.

Station mark: A cut marble post 24 by 4 by 4 inches sunk 24 inches in the ground. "U. S. G. S." marked on top of post.

[Latitude 40° 19′ 53.80″. Longitude 80° 51′ 19.20″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Cadiz C. H	61 46 20.94	241 40 48.88	4.1388232
Cadiz	69 46 06.04	249 40 19.70	4.1295800
Jefferson	137 22 06.82	317 18 11.04	4.1028039
Wintersville	233 31 31.07	53 36 19.99	4.1166735
New Alexander	290 17 09.61	110 23 39.92	4.1817202
Mount Pleasant	345 17 50.68	165 20 26.93	4.3534510

NEW ALEXANDER, JEFFERSON COUNTY.

Situated 1 mile southwest of the village of New Alexander in a cleared field on west side of county road one-fourth mile beyond point at which it leaves the New Alexander and Bloomingdale pike.

Station mark: A cut marble post 24 by 6 by 6 inches sunk 2 feet under surface of the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

Reference marks: A large tree, true bearing N. 53° 20′ E., distant 272 feet. A small tree, true bearing S. 1° 36′ W., distant 131 feet. An old stump in field, true bearing N. 68° 36′ W., distant 14.7 feet.

[Latitude 40° 17′ 02.55″. Longitude 80° 41′ 15.83″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mount Pleasant	27 21 07.51	207 17 14.17	4.2700856
Hopedale	110 23 39.92	290 17 09.61	4.1817202
Wintersville	164 08 12.73	344 06 30.92	4.1325490
Independence	286 01 22.01	106 07 03.27	4.1133566
West Liberty	327 04 20.90	147 07 42.89	4.1338982

WINTERSVILLE, JEFFERSON COUNTY.

Situated 2 miles northwest of the village of Wintersville on a cone-shaped hill on land owned by Mr. Mayo. The Wintersville and New Richmond pike passes over east side of hill.

Station mark: A cut marble post 40 by 6 by 6 inches sunk 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 24′ 05.70″. Longitude 80° 43′ 53.11″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hopedale	53 36 19.99	233 31 31.07	4.1166735
Jefferson	94 42 21.10	274 33 35.99	4.2824762
Elder	156 33 37.87	336 29 21.35	4.3682786
Hammond	189 27 36.41	9 29 54.97	4.4836287
New Alexander	344 06 30.92	164 08 12.73	4.1325490

WRAY, LAWRENCE COUNTY.

A station in the transcontinental belt of the United States Coast and Geodetic Survey on Johnson Ridge, 2½ miles east of Marion (Aid post-office). Summit nearly cleared, giving a good view in all directions.

Station mark: A pottery pyramid buried 3 feet under ground (no surface mark 1902).

Reference marks: Drain tile pipes 4 inches in diameter, 2 feet long, filled with concrete and buried 22 inches in ground—one north, 5.93 feet distant; one south, 5.99 feet; one east, 5.98 feet; one west, 5.92 feet.

[Latitude 38° 35′ 42.24″. Longitude 82° 27′ 38.91″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wagner	177 15 29.58	357 15 02.72	4.3360952
Houck	229 30 22.22	49 35 13.43	4.1709604
Gebhardt	291 52 47.45	112 00 33.64	4.2904979

GREENLER, MEIGS COUNTY.

On a cultivated ridge in Scipio Township, 2½ miles southeast of Harrisonville and 9 miles northwest of Pomeroy. Land owned by the widow Greenler. An extended view can be had in all directions.

Station mark: A stone post 30 by 8 by 8 inches set 28 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 06′ 36.10″. Longitude 82° 05′ 37.56″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Leonard	49 22 32.39	229 17 11.56	4.2078401
McKnight	131 06 34.33	311 03 11.43	4.0103602
Townsend (2)	179 42 39.02	359 42 36.35	4.3021055
Bond			4.4013817
Melhorn	279 28 14.79	99 41 07.07	4.4750063
Finlay	337 13 28.07	157 19 00.37	4.5174129

LEONARD, MEIGS COUNTY.

On a partly timbered ridge in Salem Township, 12 miles by road west of Middleport, 4 miles north of Eno post-office. Timber interferes with view northeast and southeast, but in other directions the view is particularly good. Land owned by W. H. Leonard, who lives 300 yards north.

Station mark: A sandstone post 36 by 8 by 8 inches set 34 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

Reference mark: The poplar signal tree at roadside. True azimuth from station mark, 322° 19′; distance, 128.1 feet.

[Latitude 39° 00′ 55.06″. Longitude 82° 14′ 06.67″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Graham	6 39 15.03	186 38 36.75	4.1024633
Wagner	39 34 55.56	219 25 58.48	4.5104457
Lawler	115 35 43.20	295 28 23.01	4.2699658
Zaleski	151 46 12.85	331 39 56.21	4.4807510
McKnight	194 38 18.41	14 40 16.75	4.2510681
Greenler	229 17 11.56	49 22 32.39	4.2078401
Finlay	308 21 37.63	128 32 29.47	4.5039347

M'KNIGHT, MEIGS COUNTY.

A cleared ridge in the northwestern part of Scipio Township, 2 miles east of Carpenter post-office and 5 miles south of Albany. Land owned by Thornton McKnight.

Station mark: A bluestone post 40 by 8 by 8 inches set 38 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 10′ 14.34″. Longitude 82° 10′ 59.00″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Leonard	14 40 16.75	194 38 18.41	4.2510681
Zaleski	116 35 39.29	296 27 23.36	4.3229316
Townsend (2)	209 42 32.43	29 45 53.05	4.1858081
Greenler	311 03 11.43	131 06 34.33	4.0103602

BEALLSVILLE, MONROE COUNTY.

Situated 3 miles east of the town of Beallsville on the highest point of a bare hill on the farm of the Gale brothers.

Station mark: A cut marble post 48 by 6 by 6 inches set 40 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 50′ 49.76″. Longitude 80° 58′ 49.99″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gallaway	182 29 34.33	2 29 55.83	4.2612655
Jacobsburg	210 24 53.13	30 28 36.52	4.2108474
Myers	221 32 26.97	41 39 03.80	4.3447990
Riggs	269 45 19.11	89 53 56.89	4.2835700
Wiedman	87 09 57.20	267 02 01.79	4.2471021
Newcastle	118 21 49.78	298 18 11.29	3.9639688
Steele	125 11 13.00	305 01 44.45	4.4179181
Bryan	155 16 01.67	335 13 05.87	4.1914760

CALLAND, MONROE COUNTY.

Situated on a high cleared hill in Seneca Township, about 2 miles northeast of village of Summerfield, near the Noble-Monroe county line. Land owned by Mrs. Martha Calland.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 48′ 14.31″. Longitude 81° 19′ 22.61″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fulda	53 35 25.20	233 32 02.90	3.9709420
Pleasant	87 36 24.91	267 31 42.37	4.0215172
Tucker	142 01 12.68	321 58 40.51	3.9625705
Warehime	165 10 18.15	345 08 11.50	4.2628296
Steele	201 35 53.45	21 39 25.88	4.3293954
Wiedman	251 29 17.30	71 34 31.64	4.0901708

JERUSALEM SCHOOLHOUSE, MONROE COUNTY.

(Not occupied.)

Schoolhouse in Jerusalem, Sunbury Township.

Station mark: Center of cupola.

[Latitude 39° 50′ 54.00″. Longitude 81° 06′ 06.45″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wiedman	81 59 06.96	261 55 51.27	3.8653255
Newcastle	208 14 14.47	28 15 15.85	3.6820293

ST. JOHNS, MONROE COUNTY.

(Not occupied.)

St. John's Church, situated about one-half mile west of village of Miltonsburg.

Station mark: Center of church spire.

[Latitude 39° 50′ 15.20″. Longitude 81° 10′ 32.48″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Steele	163 40 24.15	343 38 16.46	4.2252598
Newcastle	237 40 56.39	57 44 48.27	4.0073924
Wiedman			2.9781631

DILLON, MONROE COUNTY.

Station mark: The chimney on Mr. J. D. Dillon's residence, 1 mile south of Way post-office.

[Latitude 39° 37′ 40.67″. Longitude 81° 10′ 31.26″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Moore	19 50 50.56	199 47 41.01	4.3215874
Laws	65 40 13.26	245 36 29.65	3.9630466
Tank	216 55 13.70	36 57 28.00	3.9554300
High Knob	282 34 05.00	102 39 53.00	4.1253100
Glass	332 17 56.67	152 19 54.03	3.9758125

HIGH KNOB, MONROE COUNTY.

(Not occupied.)

A high peak near Sisterville on Ohio side of Ohio River, having a red tank on summit, which was located by intersections.

Station mark: Center of tank.

[Latitude 39° 36′ 06.2″. Longitude 81° 01′ 25.3″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Glass	57 43 14	237 39 23	4.00930
Dillon	102 39 53	282 34 05	4.12531

TANK, MONROE COUNTY.

On the highest knob 6 miles south of Woodsfield and 5 miles northeast of Graysville. There are two tanks on top of the knob. The one located is the farthest west and is painted white.

Station mark: Center of tank.

[Latitude 39° 41′ 34.6″. Longitude 81° 06′ 43.7″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Glass	3 48 12	183 47 44	4.19380
Dillon	36 57 28	216 55 14	3.95543
Laws	51 27 48	231 21 39	4.24646

WIEDMAN, MONROE COUNTY.

Situated on a cleared hill in Malaga Township, about 2 miles southwest of village of Miltonsburg. Land owned by Mr. Wiedman.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 50′ 20.74″. Longitude 81° 11′ 11.82″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Calland	71 34 31.64	251 29 17.30	4.0901708
Tucker	100 57 09.79	280 49 22.91	4.2463136
Warehime	130 14 07.62	310 06 46.06	4.3304252
Steele	166 38 26.80	346 36 44.38	4.2146469
Newcastle	241 04 21.24	61 08 38.37	4.0370559
Beallsville	267 02 01.79	87 09 57.20	4.2471021

WOODSFIELD COURT-HOUSE, MONROE COUNTY.

(Not occupied.)

Station mark: Center of court-house cupola.

[Latitude 39° 45′ 53.10″. Longitude 81° 07′ 04.01″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wiedman	144 29 15.26	324 26 36.62	4.0061831
Beallsville	232 04 06.58	52 09 22.97	4.1730814

SAGO, MUSKINGUM COUNTY.

On a bald hill 4 miles southwest of the village of Sago, on land owned by J. W. Carnes.

Station mark: A limestone post 40 by 7 by 7 inches set 39 inches in the ground, in the center of top of which is countersunk and cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 00′ 42.40″. Longitude 81° 46′ 55.70″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kennedy	207 11 33.69	27 14 31.91	4.1566993
College	254 49 29.58	74 54 42.29	4.0771353
Claysville	311 50 42.87	131 54 42.28	4.0746717

COFFEY, NOBLE COUNTY.

Situated in Jefferson Township, about 2 miles east of Macksburg and near the Noble-Washington county line. It is on a knob at the southern end of what is locally known as Coffey Ridge. Land belongs to the Coffey Brothers. A house surrounded by a peach orchard occupies the whole summit of knob.

Station mark: A stone post 15 by 6 by 6 inches set 15 inches in the ground, with a cross cut on upper surface.

Reference mark: The south chimney of house; distance from station 69 feet; azimuth 121° 43′.

Subsurface mark: An aluminum bolt buried 2 feet below surface underneath station mark.

[Latitude 39° 38′ 20.51″. Longitude 81° 25′ 56.23″.]

To station—	Azimuth.	Back azimuth.	Log distance.
	° ′ ″	° ′ ″	*Meters.*
Dovenbacker	21 34 03.43	201 32 41.16	3.9232258
Correy	134 02 58.60	313 58 36.21	4.1340788
Fulda	188 13 57.47	8 14 46.99	4.1102507
Laws	290 04 00.35	110 10 06.45	4.1639102

CORREY, NOBLE COUNTY.

Situated in Olive Township on summit of hill known locally as Correy Knob. Land belongs to John Hughes and is covered with a peach orchard.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 43′ 27.31″. Longitude 81° 32′ 47.22″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gregg	193 41 15.25	13 43 14.30	4.2709766
Pleasant	225 47 16.75	45 51 09.15	4.0813436
Fulda	254 08 13.79	74 13 26.06	4.0823867
Coffey	313 58 36.21	134 02 58.60	4.1340788
Dovenbecker	338 41 35.73	158 44 36.15	4.2675872
Fulda Church	270 09 40.00	90 14 41.00	4.0496191

FULDA, NOBLE COUNTY.

Situated on a cleared hill in Enoch Township about 2 miles north of Fulda post-office. Land owned by Mr. Bates.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 45′ 14.16″. Longitude 81° 24′ 38.75″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Coffey	8 14 46.99	188 13 57.47	4.1102507
Dovenbecker	13 29 38.34	193 27 26.49	4.3249454
Correy	74 13 26.06	254 08 13.79	4.0823867
Pleasant	149 46 36.80	329 45 16.75	3.7718484
Tucker	188 18 59.48	8 19 49.89	4.1112795
Calland	233 32 02.90	53 35 25.20	3.9709420
Laws	326 17 40.64	146 22 57.69	4.3294759

FULDA CHURCH SPIRE, NOBLE COUNTY.

(Not occupied.)

In village of Fulda.

Station mark: Center of church spire.

[Latitude 39° 43′ 26.01″. Longitude 81° 24′ 56.52″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Correy	90 14 41.03	270 09 40.22	4.0496191
Fulda △	187 13 47.17	7 13 58.53	3.5265941

GREGG, NOBLE COUNTY.

Situated on a cleared hill in Wayne Township about 4 miles south of Senecaville and near the Noble-Seneca county line. Hill partly covered by an orchard. Land owned by Walter Gregg.

Station mark: A bowlder 20 by 10 by 8 inches set in the ground, and having a cross (+) cut on its upper surface.

Subsurface mark: A bronze triangulation tablet buried 2 feet below surface immediately underneath cross on bowlder.

[Latitude 39° 53′ 15.23″. Longitude 81° 29′ 41.50″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Correy	13 43 14.30	193 41 15.25	4.2709766
Warehime	229 51 54.19	49 56 24.57	4.1165523
Tucker	282 43 32.96	102 47 37.40	3.9679631
Pleasant	336 31 55.44	156 33 49.16	4.0254160

PLEASANT, NOBLE COUNTY.

Situated on a high hill, with a few scattering trees on its summit, in Center Township, about 2 miles southeast of Sarahsville.

Station mark: A stone post 30 by 6 by 6 inches set 30 inches in the ground, in center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 47′ 59.84″. Longitude 81° 26′ 43.92″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Correy	45 51 09.15	225 47 16.75	4.0813436
Gregg	156 33 49.09	336 31 55.44	4.0254160
Warehime	197 40 49.35	17 43 25.93	4.2799538
Tucker	212 14 38.28	32 16 48.80	3.9579200
Calland	267 31 42.37	87 36 24.91	4.0215172
Fulda	329 45 16.75	149 46 36.80	3.7718484

SUMMERFIELD SCHOOLHOUSE, NOBLE COUNTY.

(Not occupied.)

Station mark: Center of schoolhouse in village of Summerfield.

[Latitude 39° 47′ 55.47″. Longitude 81° 20′ 16.71″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tucker	150 49 58.53	330 48 01.02	3.9516327
Calland	245 41 23.24	65 42 07.87	3.1498794

TUCKER, NOBLE COUNTY.

Situated on a partly cleared hill in Seneca Township, about 3 miles northeast of Mount Ephraim post-office. Land owned by John Tucker.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 52′ 08.72″. Longitude 81° 23′ 20.21″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pleasant	32 16 48.80	212 14 38.28	3.9579200
Gregg	102 47 37.40	282 43 32.96	3.9679631
Warehime	185 11 04.50	5 11 30.20	4.0219463
Steele	226 53 52.54	46 59 57.57	4.2667725
Calland	321 58 40.51	142 01 12.68	3.9625705
Fulda	8 19 49.89	188 18 59.48	4.1112795

BALDWIN, TUSCARAWAS COUNTY.

About 7 miles northeast from Uhrichsville, on a bald hill 100 yards east of ridge road, on land owned by David Baldwin.

Station mark: A sandstone post 36 by 6 by 6 inches set 33 inches in the ground, in the center of top of which is countersunk and cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 27′ 01.37″. Longitude 81° 17′ 28″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wainwright	75 00 27.85	254 54 15.71	4.1462651
Bowerston	308 57 08.21	129 01 07.70	4.0493365
Uhrichsville	355 40 02.51	175 40 20.53	3.9386187

BOOTH, TUSCARAWAS COUNTY.

On a sharp, bald knob, 5 miles southeast from New Comerstown, one-fourth mile south from Booth post-office, and 400 feet southeast of Mr. Walters's residence, on land owned by him.

Station mark: A sandstone post 36 by 7 by 7 inches set 34 inches in the ground, in center of top of which is countersunk and cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 13′ 26.69″. Longitude 81° 32′ 56.37″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kennedy	50 57 10.87	230 51 07.97	4.2342578
Widder	103 17 39.33	283 15 05.76	3.7615799
Wasen	166 55 12.11	346 53 04.26	4.2784021
Stone Creek	179 22 08.98	359 22 03.72	4.2391088
Gilmore	228 11 04.90	48 15 13.50	4.0860014
Midway	352 05 52.54	172 07 03.12	4.2759110

GILMORE, TUSCARAWAS COUNTY.

On a bald knob one-third mile north of the village of Gilmore, 300 feet from where road elbows to east going from Gilmore.

Station mark: A sandstone post 36 by 6 by 6 inches set 33 inches in the ground, in the center of top of which is countersunk and cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 17′ 50.02″. Longitude 81° 26′ 31.76″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Widder	65 15 18.37	245 08 36.06	4.2095562
Port Washington	107 14 03.00	287 11 28.00	3.7758800
Stone Creek	134 52 35.59	314 48 21.35	4.1164240
Wainwright	176 58 27.78	356 58 08.37	4.1267768
Uhrichsville	238 12 02.93	58 18 12.91	4.2004975
Tippecanoe	284 58 09.52	105 05 05.88	4.1973700
Booth	48 15 13.50	228 11 04.90	4.0860014

PORT WASHINGTON, TUSCARAWAS COUNTY.

(Not occupied.)

A lone tree on prominent bald mound about 2 miles south of the village of Port Washington, on east side of river.

Station mark: Center of lone tree.

[Latitude 40° 18′ 47.30″. Longitude 81° 30′ 33.18″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Widder	46 27 45	226 23 39	4.09426
Wasen	138 16 26	318 12 55	4.06184
Stone Creek	154 24 37	334 22 59	3.91720
Gilmore	287 11 28	107 14 03	3.77588

STONE CREEK, TUSCARAWAS COUNTY.

On a bald mound 1¼ miles southeast of the village of Stone Creek, 100 yards east of road.

Station mark: A sandstone post 36 by 6 by 6 inches set 34 inches in the ground, in center of top of which is countersunk and cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 22′ 48.92″. Longitude 81° 33′ 04.48″.]

To station	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Widder	18 43 44.26	198 41 15.69	4.2281117
Wasen	105 39 23.20	285 37 30.42	3.6297872
Wainwright	244 04 51.38	64 08 46.51	3.9781630
Gilmore	314 48 21.35	134 52 35.59	4.1164240
Port Washington	334 22 59.00	154 24 37.00	3.9172000
Booth	359 22 03.72	179 22 08.98	4.2391088

UHRICHSVILLE, TUSCARAWAS COUNTY.

On a bald hill about 4 miles nearly east from Uhrichsville, 200 feet west of Ridge road, on land owned by Mr. Cox, and 200 yards north of his residence.

Station mark: The lone white oak signal tree 14 inches in diameter.

Reference mark: A sandstone post 36 by 6 by 6 inches set 30 inches in the ground, in center of top of which is countersunk and cemented a bronze triangulation tablet, "Ohio." Distance from tree, 26.6 feet; true azimuth 56° 10′ 30″.

[Latitude 40° 22′ 20.70″. Longitude 81° 17′ 00.20″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gilmore	58 18 12.91	238 12 02.93	4.2004975
Wainwright	109 32 49.03	289 26 19.17	4.1775531
Baldwin	175 40 20.53	355 40 02.51	3.9386187
Bowerston	258 40 32.66	78 44 13.95	3.9146861
Tippecanoe	352 09 53.49	172 10 40.33	4.0986574

WAINWRIGHT, TUSCARAWAS COUNTY.

In a field owned by the Wainwright Coal Company, and about 1½ miles west of the mine and post-office of same name.

Station mark: A sandstone post 36 by 6 by 6 inches set 34 inches in the ground, in the center of top of which is countersunk and cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 25′ 03.52″. Longitude 81° 27′ 01.78″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Stone Creek	64 08 46.51	244 04 51.38	3.9781630
Wasen	76 42 24.37	256 36 36.39	4.1142974
Baldwin	254 54 15.71	75 00 27.85	4.1462651
Uhrichsville	289 26 19.17	109 32 49.03	4.1775531
Gilmore	356 58 08.37	176 58 27.78	4.1267768

WASEN, TUSCARAWAS COUNTY.

About 2½ miles nearly west from the village of Stone Creek on high knob in field 400 feet southeast from Mr. Wasen's residence.

Station mark: A sandstone post 36 by 6 by 6 inches set 36 inches in the ground, in center of top of which is countersunk and cemented a bronze triangulation tablet, "Ohio."

[Latitude 40° 23′ 26.19″. Longitude 81° 35′ 58.61″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Widder	4 22 43.79	184 22 07.82	4.2359074
Wainwright	256 36 36.39	76 42 24.37	4.1142974
Stone Creek	285 37 30.42	105 39 23.20	3.6297872
Port Washington	318 12 55.00	138 16 26.00	4.0618400
Booth	346 53 04.26	166 55 12.11	4.2784021

LAWLER, VINTON COUNTY, NEAR JACKSON COUNTY LINE.

A secondary station on a flat, partly timbered ridge 8 miles by road east-southeast of Wellston post-office. Land owned by Frank Lawler, but rented by Jim Kennison.

Station mark: South chimney on two-story house with red tin roof.

[Latitude 39° 05′ 15.32″. Longitude 82° 25′ 45.35″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Davis	20 28 23.27	200 26 28.47	4.0984524
Leonard	295 28 23.01	115 35 43.20	4.2699658
Graham	323 15 25.71	143 22 07.04	4.4097687

ZALESKI, VINTON COUNTY.

A knob locally well known as the Pinnacle, 1½ miles south of Zaleski railroad station. Nearly all timber was cut down and one chestnut tree left for signal. An extended view can be had in all directions, excepting north 30° east to north 55° east, which is limited by a flat timbered ridge 2 miles distant.

Station mark: A marble post 30 by 6 by 6 inches set 20 inches in the ground, top marked,

U | S
C & G | S

Reference mark: The chestnut signal tree; azimuth from station mark, 237° 08′; distance, 32.8 feet.

[Latitude 30° 15′ 18.96″. Longitude 82° 24′ 03.47″.]

To station—	Azimuth	Back azimuth	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Barton	158 09 14.12	338 05 36.66	4.3433070
McDaniel	205 26 11.15	25 29 15.51	4.2098137
Townsend (2)	261 26 53.85	81 38 31.23	4.4264864
McKnight	296 27 23.36	116 35 39.29	4.3229316
Leonard	331 39 56.21	151 46 12.85	4.4807510

DOVENBECKER, WASHINGTON COUNTY.

Situated about 5 miles southwest of Macksburg in pasture field on a high, cleared hill. Land owned by William Dovenbecker.

Station mark: A sandstone post 48 by 6 by 6 inches set 48 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 34′ 07.79″. Longitude 81° 28′ 05.23″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Correy	158 44 36.15	338 41 35.73	4.2675872
Fulda	193 27 26.49	13 29 38.34	4.3249454
Coffey	201 32 41.16	21 34 03.43	3.9232258
Laws	260 32 30.54	80 39 58.60	4.2307093
Moore	306 00 36.00	126 08 37.09	4.3492957

LAWS, WASHINGTON COUNTY.

Situated on a high, cleared, flat-topped hill in Liberty Township, about three-quarters of a mile south of the village of Lebanon. Land owned by Mr. Laws.

Station mark: A dead oak tree.

Reference mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in the center of the top of which is cemented a bronze triangulation tablet, "Ohio." Distance to center of tree, 1.4 feet; true azimuth, 170° 43′.

[Latitude 39° 35′ 37.83″. Longitude 81° 16′ 21.98″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pinkerton	50 51 42.70	230 41 51.34	4.4572810
Dovenbecker	80 39 58.60	260 32 30.54	4.2307093
Coffey	110 10 06.45	290 04 00.35	4.1639102
Fulda	146 22 57.69	326 17 40.64	4.3294759
Moore	355 27 25.12	175 27 58.83	4.2038199

GLASS, WASHINGTON COUNTY.

On north end of ridge, 0.5 mile east of Glass post-office and 100 feet south of road.

Station mark: A sandstone post 36 by 8 by 8 inches set 36 inches in the ground, with cross cut in center of top.

Reference mark: Chimney on a small frame house owned by John *Newell,* 14 feet south of station mark.

[Latitude 39° 33′ 09.09″. Longitude 81° 07′ 27.10″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Moore	45 26 59.54	225 21 53.00	4.2086840
Laws	109 48 40.00	289 42 59.25	4.1324413
Dillon	152 19 54.03	332 17 56.67	3.9758125
Tank	183 47 44.00	3 48 12.00	4.1938000
High Knob	237 39 23.00	57 43 14.00	4.0093000

MOORE, WASHINGTON COUNTY.

Situated 4 miles north of Newport, Ohio, on a high cleared knob owned by Mr. Moore and known locally as Moore's Hill.

Station mark: A sandstone post 48 by 8 by 8 inches set 48 inches in the ground, and in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 27′ 00.99″. Longitude 81° 15′ 29.00″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pinnacle	24 47 56.51	204 43 50.23	4.3462483
Seffens	64 45 45.97	244 33 51.52	4.4743073
Pinkerton	84 46 38.67	264 36 14.56	4.3728093
Dovenbecker	126 08 37.09	306 00 36.00	4.3492957
Laws	175 27 58.83	355 27 25.12	4.2038199
Owlshead	272 39 24.48	92 50 53.05	4.4140545
McCullough	308 27 51.47	128 34 48.44	4.3030833
Griffith	354 57 28.03	174 57 55.01	4.0637096

NOLAN, WASHINGTON COUNTY.

Situated in Dunham Township, about 2 miles west of Veto post-office and 4 miles southwest of Vincent railroad station. Summit of hill occupied by house surrounded by shade and fruit trees. Land owned by R. E. Sutton.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

Reference mark: Chimney on north end of house; distance from station mark, 34 feet; true azimuth from station mark, 142° 29′ 20″.

[Latitude 39° 20′ 38.11″. Longitude 81° 42′ 39.55″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lyons	36 33 16.71	216 30 09.55	4.0753794
Bond	46 14 13.62	226 08 49.91	4.2298152
Southland	109 14 36.48	289 09 05.68	4.1212888
Goff	314 58 46.74	135 04 44.31	4.2822068
Wigal	350 54 54.61	170 56 08.43	4.2486674

PINKERTON, WASHINGTON COUNTY.

Situated about 4 miles northwest of Marietta and 2 miles south of Churchtown on Pinkerton farm, 600 feet west of Pinkerton residence.

Station mark: A sandstone post 48 by 8 by 8 inches set 48 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

[Latitude 39° 25′ 50.23″. Longitude 81° 31′ 51.42″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Goff	4 55 52.16	184 54 59.34	4.3666186
Seffens	17 59 25.94	197 57 54.99	4.0458915
Nolan	58 13 59.25	238 07 08.00	4.0836942
Dovenbecker	199 23 14.85	19 25 38.76	4.2113735
Laws	230 41 51.34	50 51 42.70	4.4572810
Moore	264 36 14.56	84 46 38.67	4.3728093
Griffith	290 46 50.36	110 57 40.75	4.4191325
Pinnacle	321 34 57.99	141 41 14.67	4.3601976

SEFFENS, WASHINGTON COUNTY.

Situated on the summit of a cleared hill in Dunham Township about 1 mile west of Constitution railroad station. Land owned by William Seffens.

Station mark: A stone post 30 by 8 by 8 inches set 30 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, "Ohio."

Reference mark: The southern one of three trees which occupy the extreme summit of hill; distance from station mark, 3.1 feet; true azimuth from station mark, 46° 22′.

[Latitude 39° 20′ 07.43″. Longitude 81° 34′ 14.77″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Nolan	94 31 08.23	274 25 48.26	4.0836942
Pinkerton	197 57 54.99	17 59 25.94	4.0458915
Moore	244 33 51.52	64 45 45.97	4.4743073
Pinnacle	292 39 17.80	112 47 04.89	4.2822967
Goff	353 29 10.61	173 29 48.59	4.1032735

PRIMARY TRAVERSE.

The following geographic positions were determined from primary traverse run by J. R. Ellis in 1902. The line starts from Loveland, Baltimore and Ohio and Pennsylvania Railway crossing located by primary traverse in 1902 and follows the Pennsylvania Railway to Middletown Junction, thence along highways to Little Muddy Creek on Cincinnati, Lebanon and Northern Railway, following this road 3 miles, thence along highways to Red Lion, thence west through Blue Ball and Darton, west and south through Wood and Preston, thence south and east and connected with Madisonville station.

Geographic positions along the Pennsylvania Railroad between Loveland and Middletown Junction.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Loveland railroad crossing	39 16 00.6	84 15 31.9
Road crossing north and south	39 16 51.3	84 15 35.1
Road crossing under trestle	39 18 27.7	84 15 23.5
Foster, road crossing at	39 19 19.0	84 15 03.4
Road crossing north and south	39 21 05.1	84 14 27.8
Road crossing northeast and southwest	39 22 17.2	84 14 42.3

Geographic positions along highways.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Crossroads	39 23 30.0	84 14 52.9
Road crossing north and south	39 24 34.0	84 14 35.4
Road southeast	39 26 54.6	84 14 06.4
Bridge over creek south	39 28 06.1	84 14 16.2
Red Lion, T. 3 E., R. 4 N., center section 15	39 29 28.2	84 14 55.4
T. road south	39 29 31.1	84 16 23.7
T. road north	39 29 35.7	84 17 32.2
Crossroads	39 29 36.6	84 19 00.1
Blue Ball, crossroads at	39 29 37.4	84 20 09.6

Geographic positions along highways—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. road west	39 28 26.0	84 20 32.1
Middletown and Cincinnati Railroad at road crossing	39 28 30.0	84 21 49.1
T. 3 E., R. 4 N., corner secs. 20, 26, 25, 19	39 28 34.5	84 23 44.8
Electric railway crossing	39 28 52.1	84 25 09.3
Trenton, crossing State street and Cincinnati, Hamilton and Dayton Railroad	39 28 52.6	84 27 09.9
Ts. 4 and 5 N., Rs. 3 and 4 E., corner of	39 28 51.0	84 28 35.8
Ts. 4 and 5 N., R. 3 E., corner secs. 1, 2, 35, 36	39 28 49.8	84 29 43.5
Road crossing north and south	39 29 05.2	84 30 41.9
Road crossing north and south	39 29 30.9	84 31 58.7
T. 5 N., R. 3 E., corner secs. 28, 29, 32, 33	39 29 40.2	84 33 06.7
Seven-mile station, crossing Pittsburgh, Cincinnati, Chicago and St. Louis Railroad, 1 mile northwest of	39 29 39.3	84 34 15.6
Road crossing north and south	39 29 28.0	84 36 30.5
T. road north	39 29 37.6	84 38 13.8
T. 5 N., R. 3 E., corner secs. 27, 28, 33, 34	39 29 37.7	84 38 46.7
Road north and south	39 29 34.7	84 40 49.8
T. 5 N., Rs. 1 and 2 E., T. road east near corner secs. 30, 25, 36, 31	39 29 36.6	84 41 47.2
Pike northwest and southeast	39 28 49.9	84 42 43.5
Wood, crossing of Cincinnati, Hamilton and Dayton Railroad, west of station	39 27 30.1	84 43 00.1
T. 4 N., R. 1 E., corner secs. 11, 12, 13, 14	39 26 59.2	84 43 17.9
T. 4. N., R. 1 E., corner secs. 13, 14, 23, 24	39 26 07.1	84 43 17.5
Road northwest and southeast	39 25 13.6	84 43 44.6
St. Charles T., road north at	39 23 30.6	84 44 30.3
T. 3 N., R. 1 E., corner secs. 2, 3, 10, 11	39 22 40.5	84 44 21.3
T. 3 N., R. 1 E., corner secs. 10, 11, 14, 15	39 21 48.4	84 44 21.6
Crossing Cold Wail Pike	39 20 16.5	84 44 22.8
T. road south (gravel)	39 19 00.8	84 43 50.4
Preston post-office, west end of bridge, one-half mile east of	39 16 33.8	84 43 51.9
T. 2 N., R. 1 E., corner secs. 14, 15, 22, 23	39 15 41.8	84 44 25.2
T. 2 N., Rs. 1 and 2 E., corner secs. 7, 12, 13, 18	39 16 33.9	84 42 11.4
Corner secs., numbers not given	39 16 33.8	84 41 03.9
Sater post-office, north end of iron bridge at	39 15 50.4	84 40 02.6
Sater post-office, corner sec. 1 mile southeast of	39 15 11.6	84 39 33.9
Barnesburg tollgate, crossroads at	39 13 58.5	84 37 41.4
Crossroads	39 13 15.6	84 36 04.9
Grossbeck, crossroads at	39 13 13.0	84 35 09.6
T. 3 N., R. 1 E., corner secs. 26, 32, 31, 25	39 13 05.3	84 32 57.7
Carthage, crossing Fifth street and Cincinnati, Hamilton and Dayton Railroad	39 11 54.5	84 28 56.9
Madisonville station	39 09 26.0	84 23 49.0

ALABAMA-GEORGIA.

PRIMARY TRAVERSE.

The following geographic position were obtained from primary traverse run in 1902 by Mr. J. R. Ellis. The line starts from the adjusted position at Opelika, Ala., established in 1901, and follows the Western Railway of Alabama to Lagrange, Ga., thence along the Macon and Birmingham Railway to Harris, thence along the Central of Georgia Railway, via Columbus, to Opelika.

Geographic positions along the Western Railway of Alabama between Opelika and West Point.

Station.	Latitude.	Longitude.
ALABAMA.	° ′ ″	° ″
Opelika, water tank, established in 1901	32 38 25.5	85 23 23.6
Opelika, Central of Georgia Railway crossing	32 38 44.1	85 22 59.5
Forks of road, crossing at	32 39 18.8	85 22 28.4
Road crossing east and west	32 40 42.6	85 22 08.6
White, road crossing at	32 41 57.8	85 20 49.7
Road crossing east and west	32 43 11.2	85 19 47.2
Road crossing east and west	32 44 14.3	85 19 39.9
Road crossing east and west	32 45 07.5	85 19 42.5
Road crossing east and west	32 46 07.0	85 19 23.9
Cosseta station	32 47 03.1	85 18 27.4
Road crossing east and west	32 47 35.3	85 16 40.1
Road crossing east and west	32 48 25.9	85 15 16.4
Road crossing east and west	32 49 16.0	85 14 10.0
Road crossing east and west	32 49 42.1	85.13 18.3
Road crossing east and west	32 50 48.2	85 12 36.5
Chattahoochee Valley Railway crossing	32 51 16.1	85 11 31.3
Alabama-Georgia, State line, crossing of	32 52 14.7	85 11 08.8

Geographic positions along the Atlanta and West Point Railroad between West Point and Lagrange.

Station.	Latitude.	Longitude.
GEORGIA.	° ′ ″	° ′ ″
West Point station	32 52 31.8	85 11 01.6
Road crossing east and west	32 53 13.0	85 09 46.3
Road crossing east and west	32 54 38.5	85 08 40.0
Gabbettville station	32 56 41.6	85 08 02.0
Road crossing east and west	32 57 26.1	85 07 15.5
Road crossing north and south	32 57 56.5	85 06 19.6
Road crossing north and south	32 58 28.4	85 04 21.1
Road crossing northeast and southwest	32 58 57.1	85 03 54.6
Road crossing east and west	33 00 34.7	85 02 52.9
Lagrange station	33 02 08.1	85 01 46.4

Geographic positions along the Macon and Birmingham Railway between Lagrange and Harris.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Road crossing east and west	33 02 36.1	85 00 27.8
Western Railway of Alabama crossing	33 02 38.1	84 59 40.3
Road crossing north and south	33 02 32.7	84 58 13.3
Road crossing north and south	33 02 29.7	84 56 53.0
Mutual, north and south road crossing at	33 03 13.1	84 55 24.5
Road crossing	33 02 24.1	84 53 21.8
Mountville station	33 02 24.5	84 52 34.3
Road crossing east and west	33 02 17.2	84 51 33.8
Road crossing north and south	33 01 58.0	84 50 33.6
Road crossing northeast and southwest	33 01 10.3	84 49 28.6
Road crossing north and south	33 00 31.4	84 48 55.7
Road crossing north and south	32 59 44.7	84 47 28.0
Road crossing north and south	32 58 49.7	84 45 30.1
Road crossing north and south	32 58 24.3	84 44 13.1
Harris, Central of Georgia Railway crossing	32 58 05.7	84 42 47.5

Geographic positions along Central of Georgia Railway from Harris, Ga., via Columbus, to Opelika, Ala.

Station.	Latitude.	Longitude.
GEORGIA.	° ′ ″	° ′ ″
Road crossing north and south	32 56 21.2	84 43 46.0
Road crossing north and south	32 55 45.9	84 44 19.2
Stinson blacksmith shop, road crossing near	32 55 21.4	84 46 04.5
Road crossing east and west	32 54 18.5	84 47 31.7
Brandywine, north and south road crossing at	32 53 38.3	84 48 21.9
Road crossing north and south	32 52 56.6	84 49 19.1
Road crossing east and west	32 52 54.7	84 50 26.4
Chipley station	32 51 53.8	84 51 18.0
Road crossing east and west	32 51 06.9	84 50 49.2
Trestle, road crossing under	32 50 05.5	84 50 28.4
Tip Top, road crossing at	32 48 12.9	84 52 10.4
Road crossing east and west	32 46 49.6	84 53 16.5
Hamilton station	32 45 37.3	84 52 37.0
Road crossing north and south	32 44 42.5	84 52 15.0
Road crossing north and south	32 43 52.2	84 52 31.8
Road crossing east and west	32 42 36.5	84 52 31.4
Road crossing east and west	32 40 58.9	84 52 05.8

Geographic positions along Central of Georgia Railway, etc.—Continued.

Station.	Latitude.	Longitude.
GEORGIA—continued.	° ′ ″	° ′ ″
Road crossing north and south	32 39 20.3	84 52 06.6
Mobley, road crossing at	32 38 43.8	84 52 49.7
Road crossing east and west	32 37 35.3	84 54 26.5
Forston, north and south road crossing at	32 36 26.7	84 56 13.0
Road crossing east and west	32 35 35.5	84 56 41.0
Trestle 9 B, road crossing under	32 34 38.0	84 56 49.2
Nankipoo, road crossing at	32 33 24.5	84 56 45.7
Road crossing east and west	32 32 27.0	84 57 25.1
Road crossing northeast and southwest	32 31 38.4	84 57 58.8
Road crossing	32 30 26.9	84 58 51.5
Columbus, First avenue crossing	32 28 39.1	84 59 29.8
Phoenix station	32 28 38.8	85 00 26.7
ALABAMA.		
Road crossing east and west	32 29 28.1	85 01 52.4
Road crossing north and south	32 29 59.0	85 03 00.1
Road crossing northwest and southeast	32 31 13.4	85 04 37.9
Smith station	32 32 12.9	85 05 40.8
Road crossing east and west	32 33 17.7	85 07 15.9
Road crossing north and south	32 34 48.3	85 10 01.2
Panstown, north and south road crossing at	32 35 04.7	85 11 02.5
Road crossing east and west	32 35 37.2	85 13 10.8
Salem station	32 35 49.6	85 14 18.8
Road crossing east and west	32 36 19.3	85 15 48.2
Road crossing over railway	32 37 23.3	85 17 19.7
Road crossing north and south	32 37 30.3	85 18 49.7
Chewachee station	32 37 12.3	85 20 14.8
Road crossing east and west	32 37 18.[illegible]	85 21 36.3

KENTUCKY.

PRIMARY TRAVERSE.

The following geographic positions were determined from primary traverse run in 1902 by Mr. J. R. Ellis. The line starts from the United States Coast and Geodetic Survey astronomic pier at Henderson and follows the Louisville and Nashville Railway to Elmwood, thence east and north along highways to Floral and connects with the line run in 1900.

Geographic positions along the Louisville and Nashville Railway between Henderson and Elmwood.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Henderson astronomic pier	37 50 24.8	87 35 26.1
Henderson, Washington street, crossing of	37 49 45.6	87 34 32.0
Road crossing north and south	37 48 27.7	87 34 29.7
Road crossing east and west	37 47 01.7	87 34 35.4
Road crossing, private	37 46 06.2	87 34 25.3
Road crossing	37 44 18.4	87 33 59.2
Road crossing east and west	37 42 47.5	87 33 37.1
Road crossing, private	37 41 18.5	87 33 06.7
Robard station	37 40 33.3	87 32 46.1
Road crossing east and west	37 39 04.6	87 32 14.3
Road crossing	37 37 20.6	87 31 30.4
Sebree, Main street crossing of	37 36 30.1	87 31 47.3
Road crossing	37 35 54.0	87 31 50.2
Road crossing east and west	37 35 10.2	87 31 25.9
Road crossing east and west	37 33 48.2	87 31 31.4
Road crossing east and west	37 33 05.4	87 31 23.9
Elmwood, road, crossing at	37 31 42.7	87 29 24.8

Geographic positions along highways between Elmwood and Floral.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Crossroads	37 30 47.2	87 29 46.2
Belcourt, road north at	37 31 54.4	87 28 40.4
T. road east	37 32 53.9	87 27 57.0
T. road east	37 33 05.9	87 27 06.4
Ashby's store, road south at	37 33 19.0	87 26 10.2
T. road south	37 32 38.2	87 25 20.5
Ashbyburg, Leodguard's store, road crossing at	37 32 02.9	87 22 01.8
Road north	37 31 43.2	87 20 45.1
Shutt's Chapel, road in front of	37 31 43.4	87 19 40.0
Road south	37 31 59.4	87 18 30.4
Three roads, junction of	37 31 17.1	87 17 00.2
Rumsey, road south at	37 31 50.5	87 15 37.1
Road south	37 30 35.7	87 13 09.5
Road south	37 30 23.5	87 12 07.5
Road north and south	37 30 04.7	87 09 56.2
Crossroads	37 30 04.9	87 09 12.9
Livermore; Sixth and Main streets, crossing of	37 29 31.0	87 08 05.5

Geographic positions along highways between Elmwood and Floral—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Railway crossing	37 30 12.6	87 07 13.9
Nuckols, railway crossing at	37 31 26.0	87 06 54.6
Hillside schoolhouse, T. road, 900 feet north of	37 31 21.4	87 05 25.6
Crossroads	37 30 55.8	87 04 07.6
Schoolhouse, T. road, 400 feet south of	37 30 34.3	87 02 32.0
Crossroads	37 30 21.2	87 01 06.2
Heflin post office	37 30 25.6	87 00 25.7
Road north	37 29 57.9	86 58 58.0
Noe Creek post-office, road south at	37 28 58.1	86 58 10.1
T. road south	37 28 39.6	86 56 39.4
Hartford; Union and Market streets, corner of	37 27 07.5	86 54 29.6
Hayti schoolhouse T. road south at	37 27 25.0	86 53 42.3
T. road west	37 27 41.9	86 52 32.3
Crossroads	37 28 31.0	86 51 34.8
Road north	37 29 26.2	86 50 15.2
Jingo post-office, junction roads at	37 29 58.7	86 48 26.4
Road west	37 31 33.2	86 47 54.8
Sulphur Springs, crossroads at	37 32 10.9	86 46 33.4
Dundee, T. road west at	37 33 32.6	86 46 19.3
Road east	37 34 34.6	86 46 19.6
Bacham schoolhouse, crossroads at	37 35 19.8	86 46 23.0
Farmers' store, road southeast at	37 37 08.3	86 47 18.1
Friendship Church, crossroads at	37 38 33.1	86 46 24.0
Reynolds, railway crossing at	37 39 43.4	86 45 46.6
Haynesville, forks of road at	37 41 06.3	86 45 20.3
Lyonia, crossroads 1 mile west of	37 42 31.4	86 45 46.7
Catholic Church, crossroads northeast of	37 43 23.9	86 46 34.3
T. road east	37 44 18.1	86 47 36.4
Pellville, entrance to cemetery, T. road south at	37 45 13.8	86 48 32.0

Line from the United States Coast and Geodetic Survey astronomic pier at Henderson along the Illinois Central Railway to Morganfield and Uniontown, across the Ohio River, to a land-survey corner in Indiana.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Henderson astronomic pier	37 50 24.8	87 35 26.1
Henderson, Madisonville road crossing	37 49 02.5	87 35 00.4
Road crossing under trestle	37 47 41.8	87 37 08.6
Cedar Grove, road crossing at	37 47 27.9	87 38 03.0

Line from Henderson across Ohio River—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Wilson, road crossing at	37 46 52.4	87 39 19.6
Corydon, Negro Church, road crossing at	37 44 50.1	87 41 51.3
Dixie, road crossing at	37 44 08.4	87 42 03.0
Road crossing north and south	37 43 16.0	87 43 18.3
Highland station	37 43 17.2	87 44 34.4
Road crossing north and south	37 43 11.2	87 46 11.3
Road crossing north and south (telephone line)	37 42 55.0	87 48 19.7
Road crossing northwest and southeast	37 42 40.9	87 49 13.1
St. Vincent, road crossing at	37 42 22.8	87 50 21.3
Flournoy station	37 41 53.7	87 51 36.0
Road crossing northwest and southeast	37 41 41.4	87 52 49.9
Morganfield brickyard, road crossing at	37 41 25.5	87 54 26.3
Road crossing east and west	37 42 55.3	87 54 50.7
Road crossing east and west	37 44 00.3	87 55 15.1
Road crossing north and south	37 45 10.2	87 55 35.2
Uniontown, Mill street crossing of	37 46 06.2	87 55 53.9
INDIANA.		
T. 8 S., R. 14 W., ¼ corner between secs. 35 and 36	37 47 01.9	87 56 46.9

Line from the adjusted position at Nuckols along the Louisville and Nashville Railway to Owensboro, connecting with position determined by primary traverse in 1899.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Nuckols, railway crossing at	37 31 26.0	87 06 54.6
Road crossing north and south	37 32 34.8	87 06 25.4
Livia station	37 34 07.4	87 06 00.7
Road crossing east and west	37 34 41.3	87 05 50.7
Road crossing northeast and southwest	37 35 55.8	87 06 25.7
Road crossing east and west	37 37 18.2	87 07 11.2
Road crossing east and west	37 38 24.4	87 07 03.3
Sutherland, road crossing at	37 40 15.7	87 07 13.3
Road crossing east and west	37 41 36.6	87 07 10.2
Road crossing east and west	37 42 33.5	87 06 59.7
Owensboro, Hickman Park, road crossing at	37 44 29.2	87 06 23.7

MISSISSIPPI.

PRIMARY TRAVERSE.

The following geographic positions were determined from primary *traverse by Mr. J. R.* Ellis in 1902 and 1903. The line between Vicks*burg and Jackson* was run and duplicated, giving a double value for

Jackson which was based on United States Mississippi River Commission triangulation station Trinity Church spire. This line follows the Alabama and Vicksburg Railway. A spur line was run northward from Jackson along the Yazoo and Mississippi Valley Railway to Pocahontas. A spur line was also run southward from Jackson following the Illinois Central Railway to the line between Hinds and Copiah counties. Another line was run eastward from Jackson along the Alabama and Vicksburg Railway to range line between Rs. 3 and 4 E.

Geographic positions along the Alabama and Vicksburg Railway between Vicksburg and Jackson.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Vicksburg, Trinity Church spire	32 20 49.2	90 52 49.5
Overhead road crossing north and south	32 20 24.2	90 50 58.5
Beechwoods, road crossing at	32 19 44.1	90 48 49.2
Overhead road crossing north and south	32 20 12.6	90 47 38.1
Newman, north and south road crossing at	32 20 43.9	90 46 15.8
Road crossing north and south	32 20 50.7	90 45 29.3
Bovina station	32 21 04.2	90 44 06.5
Road crossing east and west	32 20 42.3	90 42 52.0
T. 6 N., R. 5 W., corner secs. 22, 23, 26, 27	32 20 31.7	90 41 23.3
Smith station	32 20 21.1	90 40 24.9
Road crossing north and south	32 20 07.3	90 39 19.7
Road crossing north and south	32 19 54.6	90 38 06.3
Edwards, Main street, crossing of	32 19 46.3	90 36 21.7
Road crossing northwest and southeast	32 19 55.1	90 34 58.2
T. 6 N., Rs. 4 and 3 W., corner secs. 19, 24, 25, 30	32 20 29.0	90 33 22.1
T. 6 N., R. 3 W., ¼ corner between secs. 20, 21	32 20 56.7	90 31 11.3
Sec. corner (no numbers)	32 20 56.6	90 29 07.5
Bolton station	32 20 50.2	90 27 29.1
Road crossing north and south	32 21 03.1	90 25 45.3
T. 6 N., R. 2 W., corner secs. 15, 16, 21, 22	32 21 22.9	90 23 58.9
Stone culvert, U. S. Coast and Geodetic Survey bench mark on	32 20 50.1	90 20 19.9
T. 6 N., R. 1 W., corner secs. 19, 20, 29, 30	32 20 29.3	90 19 50.3
Road crossing northeast and southwest	32 20 02.6	90 17 40.3
Dixon, north and south road crossing at	32 19 30.4	90 15 12.2
T. 6 N., R. 1 E., corner secs. 29, 30, 31, 32	32 19 37.1	90 13 43.2
Jackson, north and south road crossing, 1 mile northwest of	32 19 05.9	90 12 39.0

Geographic positions along the Illinois Central Railway from Jackson to line between Hinds and Copiah counties.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Jackson station	32 18 01.3	90 11 30.6
Jackson, Illinois Central and Alabama and Vicksburg railways, crossing of	32 17 54.9	90 11 30.0
T. 5 N., R. 1 E., corner secs. 3, 4, 9, 10	32 17 48.2	90 11 35.6
Road crossing east and west	32 16 19.3	90 12 26.3
Road crossing east and west	32 14 51.6	90 12 38.8
Pearl, road crossing east and west at	32 13 12.2	90 13 12.2
Road crossing east and west	32 11 45.3	90 13 47.5
Byram station	32 10 44.7	90 14 41.4
Road crossing east and west	32 09 30.5	90 15 26.4
Road crossing east and west	32 07 13.8	90 16 15.3
Road crossing east and west	32 06 03.7	90 17 14.6
Terry station	32 05 38.8	90 17 38.0
Road crossing east and west	32 04 52.5	90 18 21.3
Road crossing east and west	32 04 02.3	90 19 08.3
Ts. 2 and 3 N., R. 1 W., corner secs. 5, 6, 31, 32	32 02 56.3	90 19 52.8
Hinds and Copiah county line, crossing of	32 02 54.9	90 20 04.9

Geographic positions along the Alabama and Vicksburg Railway from Jackson eastward to line between ranges 3 and 4.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Road crossing east and west	32 16 31.6	90 09 59.2
Road crossing north and south	32 15 33.3	90 09 12.0
Pearson, road crossing at	32 14 48.8	90 07 56.4
Road crossing north and south	32 14 33.1	90 06 47.4
Road crossing north and south	32 14 06.0	90 05 33.1
Road crossing north and south	32 14 09.5	90 04 22.5
Greenfield, road crossing east and west at	32 14 53.9	90 03 13.7
Rice, station-board	32 15 59.0	90 02 18.7
Road crossing north and south	32 16 43.5	90 00 17.9
Brandon station	32 17 08.0	89 59 44.4
Road crossing north and south	32 17 28.6	89 58 39.3
T. 5 N., Rs. 3 and 4 E., ¼ corner between secs. 7 and 12	32 17 25.4	89 56 15.4

Geographic positions along the Yazoo and Mississippi Valley Railway from Jackson northeastward.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Road crossing east and west	32 19 33.9	90 11 15.3
Road crossing northeast and southwest	32 20 24.3	90 11 54.1
T. 6 N., R. 1 E., corner secs. 16, 17, 20, 21	32 21 19.4	90 12 37.4
Road crossing northeast and southwest	32 22 00.0	90 13 15.5
Road crossing north and south	32 23 09.9	90 14 01.4
Cynthia, road crossing at	32 24 03.6	90 14 55.2
Greene Crossing, road east and west	32 26 12.6	90 16 00.3
Road crossing east and west	32 27 22.5	90 16 46.3
Pocahontas station	32 28 19.5	90 17 16.9
Hinds and Madison county line, crossing of	32 29 13.1	90 17 19.0
Ts. 7 and 8 N., R. 1 W., corner secs. 2, 3, 34, 35	32 29 13.7	90 16 43.3

ILLINOIS.

PRIMARY TRAVERSE.

The following geographic positions were determined by primary traverse run in 1902 by Mr. J. R. Ellis. Starting from adjusted position of the Chicago, Peoria and St. Louis Railway station at Havana, the line follows that railway to a point about 3.5 miles northeast of Parkland, thence east along wagon roads to southeast corner of Peoria quadrangle, thence north to Morton, thence north on Vandalia Railway to Farmdale, thence north and west through Peoria, thence west and south by wagon roads to Reed City, thence east by Toledo, Peoria and Western Railway to Pekin, thence southwest to point where line first left railway over Chicago, Peoria and St. Louis Railway.

Geographic positions along the Chicago, Peoria and St. Louis Railway.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Havana station	40 17 37.2	90 03 56.0
Road crossing north and south (private)	40 29 51.3	89 43 07.1

Geographic positions along highways.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. 24 N., R. 5 W., corner secs. 29, 30, 31, and 32	40 29 37.0	89 42 07.7
T. 24 N., R. 5 W., corner secs. 28, 29, 32, and 33	40 29 38.7	89 40 58.3
T. 24 N., R. 5 W., corner secs. 26, 27, 34, and 35	40 29 39.9	89 38 41.2
T. 24 N., R. 5 W., corner secs. 25, 26, 35, and 36	40 29 40.4	89 37 32.7

Geographic positions along highways—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Ts. 23 and 24, N. Rs. 4 and 5 W., corner of	40 28 49.2	89 36 22.5
T. 24 N., R. 4 W., corner secs. 28, 29, 32, and 33	40 29 41.8	89 34 05.5
T. 24 N., R. 4 W., corner secs. 27, 28, 33, and 34	40 29 42.2	89 32 58.2
T. 24 N., R. 4 W., corner secs. 26, 27, 34, and 35	40 29 42.9	89 31 49.9
T. 24 N., R. 4 W., corner secs. 25, 26, 35, and 36	40 29 43.4	89 30 42.3
T. 24 N., R. 3 and 4 W., corner secs. 25, 30, 31, and 36	40 29 43.9	89 29 34.4
T. 24 N., R. 4 W., ¼ corner between secs. 25 and 30	40 30 10.6	89 29 34.7
Road, corner in	40 30 11.5	89 28 18.6
Road east and west	40 31 30.0	89 28 20.1
T. 24 N., R. 4 W., corner secs. 7, 8, 17, and 18	40 32 22.1	89 28 37.7
T. 24 N., R. 4 W., corner secs. 5, 6, 7, and 8	40 33 14.4	89 28 38.9
Ts. 24 and 25 N., R. 4 W., corner secs. 5, 6, 31, and 32	40 34 06.6	89 28 42.2
Maple Grove schoolhouse, road corner at	40 35 25.3	89 28 30.6

Geographic positions along the Vandalia Railway.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Morton crossing of Tremont and St. Louisa Rilway	40 36 30.7	89 27 48.1
Road crossing east and west	40 37 25.5	89 29 00.2
Road crossing east and west	40 39 35.8	89 30 06.3
Road crossing north and south	40 40 16.1	89 31 21.5

Geographic positions along highways.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Three roads, junction of	40 40 57.7	89 33 13.4
Creek northwest, bridge over	40 41 41.8	89 32 26.7
Creek west, bridge over	40 42 49.0	89.31 46.6
Crossroads	40 43 30.7	89 31 24.5
T. 26 N., R. 4 W., corner secs. 1, 2, 11, and 12	40 43 56.8	89 31 18.8
Pitt and mound 45 feet south of road on top of hill	40 43 58.2	89 30 30.8
Illinois River, center draw to wagon bridge, over	40 43 27.9	89 32 52.9
Peoria, North Perry street and Abingdon avenue, corner of	40 42 35.3	89 34 17.6
Peoria, Knoxville, and Frye avenues, corner of	40 42 44.4	89 35 38.8
Peoria, Elizabeth, and Nebraska avenues, corner of	40 42 37.9	89 36 13.5

Geographic positions along highways—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Peoria, Main and Franklin streets, corner of	40 41 59.4	89 36 33.6
Road west	40 42 17.0	89 38 08.9
Pottstown, railway crossing at	40 43 05.3	89 39 39.5
T. 9 N., R. 7 E., ¼ corner between secs. 27 and 34	40 43 32.1	89 41 23.3
T. 9 N., R. 11 E., corner secs. 27, 28, 33, and 34	40 43 32.2	89 41 57.6
T. road north	40 43 32.3	89 43 06.7
T. road east	40 43 06.1	89 44 50.1
Ts. 8 and 9 N., R. 7 E., ¼ corner between secs. 6 and 31	40 42 39.9	89 44 50.6
Hale, crossing Iowa Central Railway at	40 41 29.3	89 44 49.6
T. 8 N., Rs. 6 and 7 E., corner 7, 12, 13, and 18	40 40 55.1	89 45 25.2
Gravel road east and west	40 39 38.3	89 46 07.6
Ts. 7 and 8 N., Rs. 6 and 7 E., corner of	40 37 27.0	89 45 24.4
T. road east	40 36 20.8	89 45 23.6
T. road east	40 35 16.0	89 45 22.9

Geographic positions along the Toledo, Peoria and Western Railway.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Reed City, railway crossing at	40 34 32.5	89 45 03.2
Road crossing north and south	40 33 59.0	89 43 50.2
Roads crossing north, east, south, and west	40 34 21.2	89 42 31.5
Road crossing east and west	40 34 48.5	89 41 30.0
Orchard Mines, road crossing at	40 35 20.1	89 40 41.5
Pekin, center of draw in wagon bridge	40 34 22.3	89 39 18.2

Geographic positions along the Chicago, Peoria and St. Louis Railway.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Chicago, Peoria and St. Louis Railway and Peoria and Pekin Union Railway, crossing of	40 33 38.8	89 39 21.8
Globe Distillery, east and west road crossing at	40 33 03.5	89 39 55.9
Road crossing east and west	40 32 16.1	89 40 44.7
T. 24 N., R. 5 W., ¼ corner between secs. 17 and 20	40 31 22.8	89 41 35.0

MICHIGAN.

PRIMARY TRAVERSE.

The following positions were obtained by primary traverse run by Mr. J. R. Ellis in 1902. Line starts from adjusted position of Plymouth railway station, located by primary traverse in 1901, and follows highways south to Monroe triangulation station of Lake Survey:

Geographic positions from Plymouth station southward.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Plymouth station	42 22 50.0	83 27 42.3
Road crossing north and south	42 22 38.4	83 30 36.0
T. road north	42 22 30.2	83 32 19.1
T. road east	42 21 49.7	83 32 53.6
Ts. 1 and 2 S., Rs. 7 and 8 E., corner of	42 20 56.7	83 32 50.3
T. 2 S., Rs. 7 and 8 E., corner secs. 1, 6, 7, 12	42 20 04.7	83 32 48.4
T. 2 S., Rs. 7 and 8 E., corner secs. 18, 7, 12, 13	42 19 12.7	83 32 46.0
T. 2 S., Rs. 7 and 8 E., corner secs. 18, 19, 24, 13	42 18 20.6	83 32 43.3
Road northeast and southwest	42 17 31.0	83 32 43.1
T. 2 S., Rs. 7 and 8 E., corner secs. 31, 30, 36, 25	42 16 35.8	83 33 15.1
T. road east	42 15 43.5	83 33 12.2
T. 3 S., Rs. 7 and 8 E., corner secs. 1, 6, 7, 12	42 14 49.5	83 32 39.7
T. 3 S., Rs. 7 and 8 E., corner secs. 7, 18, 13, 12	42 13 57.7	83 32 38.9
T. road west	42 12 49.1	83 32 36.4
Road southeast	42 11 52.7	83 32 34.4
Ts. 3 and 4 S., Rs. 7 and 8 E., corner of	42 10 27.2	83 32 31.4
T. 4 S., Rs. 7 and 8 E., corner secs. 1, 6, 7, 12	42 09 30.7	83 32 29.2
Road east and west	42 08 37.8	83 32 27.5
T. road west	42 07 45.3	83 32 26.0
T. 4 S., Rs. 7 and 8 E., corner secs. 19, 30, 25, 24	42 06 52.3	83 32 24.2
T. 4 S., Rs. 7 and 8 E., corner secs. 30, 31, 36, 25	42 06 00.0	83 32 22.7
Ts. 4 and 5 S., Rs. 7 and 8 E., corner of	42 05 07.8	83 32 21.1
T. 5 S., Rs. 7 and 8 E., corner secs. 1, 6, 7, 12	42 04 21.1	83 32 19.9
Road northwest and southeast	42 03 23.5	83 32 18.5
T. road east	42 02 06.9	83 32 16.8
Road northwest and southeast	42 01 06.9	83 32 15.4
Road west	42 00 24.5	83 31 38.1
Road east and west	41 58 52.9	83 32 07.1
T. road north	41 57 55.5	83 32 38.6
T. road southwest	41 56 54.0	83 31 47.2
T. road northwest	41 56 29.2	83 30 48.3
T. road north and south	41 56 13.5	83 29 22.7
Monroe County Poor House, crossroads, 800 feet west of	41 55 59.4	83 27 47.1
Monroe, triangulation station U. S. Lake Survey	41 55 04.3	83 28 15.3

MISSOURI.

PRIMARY TRAVERSE.

The following geographic positions were determined from primary traverse run by Mr. J. R. Ellis in 1902. The line starts from United States Coast and Geodetic Survey triangulation station Hughes and follows highways south and east to Bagnell, thence north along Missouri Pacific Railway to a point near Olean, thence north and west along highways to United States Coast and Geodetic Survey triangulation station Highpoint. Positions are given on the U. S. Standard datum:

Geographic positions along highways from Hughes triangulation station to Bagnell.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Hughes triangulation station United States Coast and Geodetic Survey	38 25 56.5	92 55 52.1
Crossroads	38 25 53.7	92 57 15.7
T. road north	38 25 47.8	92 57 59.3
T. road west	38 24 57.7	92 58 51.8
Harden Williams's residence road, east at	38 24 00.8	92 58 56.1
Road west	38 23 14.6	92 59 31.4
Spear's mill, road east and west to	38 22 07.9	92 58 58.7
Ts. 41 and 42 N., Rs. 18 and 19 W., corner of	38 21 26.1	92 57 41.9
T. road	38 18 56.7	92 56 27.0
Southeast corner field, crossroads at	38 18 15.2	92 56 57.1
County road north	38 17 24.6	92 56 38.8
T. 40 N., R. 18 W., center sec. 8	38 14 50.1	92 56 27.2
Proctors Ferry, frame house 300 yards east of, on the north bank Osage River	38 13 55.6	92 57 06.4
Road east	38 12 46.3	92 57 07.3
Ts. 39 and 40 N., Rs. 18 and 19 W., corner of	38 10 57.6	92 58 39.5
Hankins's residence, crossroads at	38 10 13.0	92 58 42.1
Road south	38 09 26.7	92 57 58.3
Signboard Ironton, 4 miles, crossroads at	38 09 09.6	92 57 26.0
Signboard Rainy Creek, 6 miles, T. road at	38 08 44.0	92 56 25.0
T. road west	38 07 17.6	92 54 32.6
Abram's store, crossroads 150 yards west of	38 06 36.2	92 54 34.3
Road south	38 06 09.0	92 53 25.4
Southwest corner of field, road north at	38 06 21.5	92 52 16.8
Corner of field, road southeast at	38 05 53.4	92 50 38.6
Signboard Climax Springs, 13 miles, crossroads at	38 05 39.3	92 49 51.4
Road north	38 05 43.8	92 49 07.3
Cemetery, east fence to	38 05 39.5	92 47 49.5
T. 39 N., R. 17 W., ¼ corner between secs. 26 and 35	38 05 00.5	92 45 42.5
Ts. 38 and 39 N., Rs. 16 and 17 W., corner of	38 04 05.9	92 44 06.8
Brumell, road east to	38 04 53.4	92 43 29.9

Geographic positions along highways, etc.—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Three roads, junction of	38 05 45.0	92 42 53.9
Road south	38 05 56.3	92 41 56.3
Damsel post-office	38 06 38.9	92 41 17.4
Schoolhouse (concrete)	38 07 35.4	92 39 57.4
Creek, forks of road in	38 07 12.1	92 38 04.4
Road east	38 07 58.7	92 37 20.1
Crossroads	38 10 11.7	92 35 15.6
Bagnell, crossroads 3 miles south of	38 11 34.8	92 34 29.0
Road east	38 12 55.9	92 35 00.2
Signboard, "Brumley 12 miles, Tuscumbia 12 miles," T. road at	38 13 07.8	92 35 26.0

Geographic positions along the Missouri Pacific Railway between Bagnell and Olean.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Bagnell station	38 13 33.4	92 36 02.8
East and west road crossing	38 14 07.7	92 37 03.9
East and west road crossing	38 14 45.4	92 35 42.5
Road crossing under trestle	38 16 22.2	92 36 23.8
North and south road crossing	38 16 54.5	92 36 28.9
Aurora station	38 18 49.7	92 35 48.8
East and west road crossing	38 19 35.1	92 36 19.3
Missouri Pacific and Chicago, Rock Island railways, crossing of	38 20 45.0	92 35 03.1
East and west road crossing	38 21 51.8	92 33 36.5
Private road crossing	38 23 48.6	92 32 45.4
North and south road crossing	38 24 14.1	92 32 20.7

Geographic positions along highways from near Olean to Highpoint triangulation station.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Telegraph line, T. road	38 24 40.6	92 32 26.2
Road west	38 26 07.2	92 32 53.2
Mett's blacksmith shop, T. road at	38 27 16.9	92 33 16.4
Creek east, bridge over	38 27 58.6	92 33 34.1
South entrance to I. O. O. F. Cemetery, road at	38 28 51.8	92 34 34.3
Highpoint triangulation station United States Coast and Geodetic Survey	38 29 29.4	92 34 59.7

KANSAS.

PRIMARY TRAVERSE.

Two 30-minute quadrangles in southeastern Kansas were controlled by 150 miles of primary traverse run by Mr. J. R. Ellis, field assistant, in 1902. Positions are based upon the astronomic station at Fort Scott.

Geographic positions along Missouri, Kansas and Texas Railway between Fort Scott and Walnut.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Fort Scott, Kans., astr. pier	37 50 25.76	94 42 26.75
Corner of Bridal Veil Park, road crossing at	37 50 26.13	94 43 21.16
Road north and south	37 49 35.72	94 45 37.37
Road north and south	37 49 00.74	94 46 09.83
Bridge 174, road crossing under	37 48 43.95	94 46 48.91
Ronald, road crossing east and west at	37 47 29.28	94 48 23.05
Road crossing east and west	37 46 36.56	94 49 16.62
T. 26 S., Rs. 23 and 24 E., corner secs. 19, 24, 25, and 30	37 45 44.29	94 49 55.73
Road crossing east and west	37 44 52.32	94 50 51.79
Road crossing east and west	37 44 00.74	94 51 43.69
Hiattville station	37 43 21.40	94 52 13.85
Road crossing north and south	37 42 45.01	94 53 14.71
T. 27 S., R. 23 E., corner secs. 8, 9, 16, and 17	37 42 16.06	94 54 21.64
Road crossing north and south	37 41 35.50	94 55 28.45
Road crossing north and south	37 40 51.48	94 56 33.10
Bourbon-Crawford county line, road crossing on	37 40 31.69	94 57 05.33
Hepler station	37 39 50.60	94 58 12.56
T. 27 S., R. 22 E., corner secs. 26, 27, 34, and 35	37 39 39.06	94 58 43.84
Ts. 27, 28 S., R. 22 E., corner secs. 33, 34, 4, and 3	37 38 46.65	94 59 49.52
Road crossing north and south	37 38 10.99	95 00 55.47
Road crossing north and south	37 37 31.19	95 02 00.47
Road crossing north and south	37 36 51.85	95 03 04.68
T. 28 S., R. 21 E., corner secs. 13, 14, 23, and 24	37 36 08.90	95 04 10.86
Walnut, Atchison, Topeka and Santa Fe Railway crossing	37 36 05.62	95 04 20.13

Geographic positions along branch line of Atchison, Topeka and Santa Fe Railway between Walnut and Chanute.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Road crossing north and south	37 36 32.17	95 05 16.67
Road crossing north and south	37 36 17.81	95 06 22.24
Road crossing north and south	37 35 30.83	95 07 27.94
Road crossing north and south	37 35 01.02	95 08 33.60
Road crossing north and south	37 34 56.03	95 09 39.19
Trent, road crossing north and south at	37 34 55.25	95 10 46.85
T. 28 S., R. 20 E., corner secs. 22, 23, 26, and 27	37 35 14.66	95 11 52.02
Road crossing north and south	37 34 55.95	95 12 57.64
Missouri, Kansas and Texas Railway, crossing of	37 34 36.67	95 14 11.54
Road crossing north and south	37 34 38.28	95 15 09.00
T. 28 S., R. 19 E., corner secs. 23, 24, 25, and 26	37 35 14.29	95 17 18.92
Road crossing north and south	37 35 42.43	95 18 24.78
Shaw station	37 36 06.71	95 19 04.10
Road crossing east and west (not public)	37 37 06.38	95 19 09.05
Rollin, north and south road crossing at	37 38 18.28	95 21 40.66
Road crossing north and south	37 38 32.84	95 22 45.64
Ts. 27, 28 S., R. 18 E., corner secs. 35, 36, 2, 1	37 38 46.10	95 23 51.46
Road crossing north and south	37 39 02.30	95 24 57.20
Missouri, Kansas and Texas Railway, crossing of	37 39 12.85	95 25 44.30
T. 27 S., R. 18 E., corner secs. 28, 29, 32, 33	37 39 39.00	95 27 09.30
Chanute, crossing of main line Atchison, Topeka and Santa Fe and Missouri, Kansas and Texas railways	37 39 53.19	95 27 28.18
Chanute station	37 40 54.95	95 27 11.20
Chanute crossing of Missouri, Kansas and Texas and Atchison, Topeka and Sante Fe railways	37 41 42.25	95 26 57.78

Geographic positions along main line Atchison, Topeka and Santa Fe Railway between Chanute and Colony.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Road crossing east and west	37 43 07.63	95 26 20.55
County line, Neosho and Allen counties, ¼ sec. corner between secs. 3 and 34, Ts. 26 and 27, R. 18 E. on	37 44 13.63	95 25 29.38
Road crossing east and west	37 45 34.88	95 25 47.38
Road crossing east and west	37 46 38.34	95 25 45.51
Road crossing northeast and southwest	37 47 34.40	95 25 43.87
Humboldt station	37 48 42.76	95 25 42.62
Road crossing east and west	37 50 07.86	95 25 38.74
Road crossing east and west	37 51 00.19	95 25 25.03
T. 25 S., R. 18 E., ¼ corner between secs. 15 and 22	37 51 52.59	95 25 06.67

Geographic positions along main line Atchison, Topeka and Santa Fe Railway between Chanute and Colony—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. 25 S., R. 18 E., ¼ corner between secs. 10 and 15	37 52 18.78	95 25 06.73
Road crossing east and west	37 53 11.20	95 24 50.67
Road crossing east and west	37 54 43.58	95 24 38.21
Iola station	37 55 21.78	95 24 38.52
Road crossing north and south	37 56 10.52	95 24 32.15
Road crossing east and west	37 57 07.15	95 24 12.70
Road crossing east and west	37 57 59.61	95 23 50.93
Trestle, crossing under	37 58 54.29	95 23 26.97
Carlisle station	37 59 43.18	95 23 16.85
Ts. 23 and 24 S., R. 18 E., corner secs. 36, 35, 2, and 1	37 59 44.80	95 23 24.64
Road crossing east and west	38 00 36.95	95 23 05.71
Road crossing east and west	38 01 29.38	95 22 52.24
Road crossing east and west	38 02 21.76	95 22 38.78
Road crossing east and west	38 03 14.32	95 22 25.27
Corner secs. 1, 6, 7, and 12	38 04 06.53	95 22 16.91
Colony station	38 04 18.14	95 22 05.61
Missouri Pacific Railway crossing	38 04 43.59	95 21 56.99

Geographic positions along Missouri Pacific Railway between Colony and Blue Mound

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Road crossing north and south	38 04 43.14	95 19 36.29
Road crossing north and south	38 04 44.04	95 18 30.36
Road crossing north and south	38 04 42.72	95 16 51.04
Road crossing north and southR	38 04 44.01	95 15 45.42
Corner secs. 5, 6, 31, and 32	38 04 53.97	95 14 35.62
Road crossing north and south	38 04 43.29	95 13 28.90
Road crossing north and south	38 04 23.51	95 11 15.72
Road crossing north and south	38 04 44.02	95 10 09.46
Kincaid station	38 04 55.46	95 09 17.53
Missouri, Kansas and Texas Railway, crossing of	38 04 56.29	95 09 01.06
Road crossing north and south	38 05 19.44	95 07 23.49
Road crossing north and south	38 05 22.10	95 06 50.32
Trestle 81, crossing under	38 05 22.09	95 05 43.28
Anderson-Linn County line, crossing on, north and south	38 05 28.78	95 04 37.69
Road crossing, north and south	38 05 34.29	95 03 31.42
Trestle 74, crossing under	38 05 33.96	95 02 25.25

Geographic positions along or near the ninety-fifth meridian between Blue Mound and Uniontown.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Road crossing north and south	38 05 33.69	95 01 30.28
Ts. 22 and 23 S., R. 22 E., ¼ corner secs. 32 and 5	38 04 54.78	95 00 57.15
Ts. 22 and 23 S., R. 22 E., corner secs. 33, 32, 4, and 5	38 04 54.92	95 00 23.68
T. 23 S., R. 22 E., corner secs. 4, 5, 8, 9	38 04 02.38	95 00 23.63
T. 23 S., R. 22 E., corner secs. 8, 9, 16, and 17	38 03 10.14	95 00 23.40
Road crossing, east and west	38 02 18.10	95 00 22.96
Road crossing, north, south, east, and west	38 01 25.87	95 00 23.66
Little Osage River, center iron bridge, over	38 01 06.40	94 59 15.97
Ts. 23 and 24 S., R. 22 E., corner secs. 33, 34, 3, and 4	37 59 40.92	94 59 16.36
Road crossing north, east, south, and west	37 57 48.22	94 59 49.13
Road junction	37 56 36.90	94 59 49.65
T. 24 S., R. 22 E., corner secs. 21, 28, 27, and 22	37 56 12.08	94 59 16.38
T. 24 S., R. 22 E., corner secs. 22, 23, 26, 27	37 56 12.23	94 58 10.98
Roads north, south, east, and west	37 55 06.88	94 57 38.19
Roads north, south, east, and west	37 54 27.65	94 57 54.62
Roads north, south, east, and west	37 53 35.46	94 57 54.77
T. 25 S., R. 22 E., corner secs. 2, 3, 10, and 11	37 53 35.18	94 58 11.31
Road junction	37 52 34.78	94 58 11.38
T. 25 S., R. 22 E., corner secs. 14, 15, 22, and 23	37 51 50.75	94 58 11.51
T. 25 S., R. 22 E., corner secs. 22, 23, 26, and 27	37 50 58.41	94 58 11.59

Geographic positions along the Missouri Pacific Railway, between Uniontown and Fort Scott.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Roads north, east, south, and west	37 50 52.72	94 57 15.18
Road crossing north and south	37 50 37.79	94 55 27.07
Road crossing north and south	37 50 20.41	94 55 02.10
Trestle 17, road crossing under, north and south	37 50 09.44	94 53 14.38
Redfield station	37 50 07.61	94 52 55.96
T. 25 S., R. 23 E., corner secs. 27, 28, 33, and 34	37 50 05.91	94 52 41.74
Road crossing north and south	37 49 52.99	94 50 29.81
Marmaton station	37 49 53.53	94 49 29.82
T. 25 S., Rs. 23 and 24 E., corner secs. 25, 30, 31, and 36	37 50 05.94	94 49 24.03
Road crossing north and south	37 50 20.90	94 48 18.32
Road crossing north and south	37 50 42.32	94 47 12.71
Road crossing north and south	37 50 48.18	94 45 50.27
Fort Scott: road crossing ½ mile west of	37 50 34.88	94 43 21.11

Geographic positions along the Atchison, Topeka and Santa Fe Railway, between Chanute and Thayer.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Chanute; Missouri, Kansas and Texas and Atchison, Topeka and Santa Fe railways, crossing of	37 39 53.19	95 27 28.18
Road crossing east and west	37 38 47.61	95 27 46.16
Road crossing east and west	37 37 53.65	95 28 00.93
T. 28 S., R. 18 E., corner secs. 7, 8, 17, and 18	37 37 01.29	95 28 14.34
Road crossing east and west	37 36 09.20	95 28 14.65
Earleton station	37 35 17.30	95 28 14.35
T. 28 S., R. 18 E., corner secs. 19, 20, 29, and 30	37 35 16.61	95 28 14.35
Road crossing east and west	37 34 23.96	95 28 14.03
Road crossing east and west	37 33 34.18	95 28 13.72
Road crossing east and west	37 32 39.36	95 28 13.39
Road crossing east and west	37 31 46.72	95 28 13.07
Road crossing east and west	37 30 54.67	95 28 12.75
Road crossing east and west	37 29 37.11	95 28 12.24
Thayer station	37 29 21.29	95 28 12.15

NORTH DAKOTA—MINNESOTA.

PRIMARY TRAVERSE.

The following geographic positions were determined from primary traverse run by Mr. Geo. T. Hawkins in 1902. The line starts from a position determined by traverse, at Fargo, and follows the Northern Pacific Railway to Warren, thence south along highways to Kindred; thence along Great Northern Railway to Colfax, thence along highways to Hankinson, thence by "Soo Line" to Fairmount, thence by Chicago, Milwaukee and St. Paul Railway to Wahpeton, thence by Great Northern Railway to starting point.

Geographic positions along the Great Northern Railway.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Fargo, crossing of Broadway and Northern Pacific Railway	46 52 25.5	96 47 08.9
Road crossing east and west on north edge of Wahpeton quadrangle	46 29 56.0	96 53 50.8
Colfax, road crossing east and west in north part of	46 28 11.8	96 52 27.1

Geographic positions along highways between Colfax and Hankinson.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Ts. 134 and 135 N., R. 49 W., corner secs. 5, 6, 31, and 32	46 27 19.6	96 52 50.1
Ts. 134 and 135 N., R. 49 W., corner secs. 17, 18, 19, and 20	46 24 42.8	96 52 47.5
Ts. 134 and 133 N., R. 49 W., corner secs. 5, 6, 31, and 32	46 22 06.3	96 52 49.3
Ts. 134 and 135 N., R. 49 W., corner secs. 17, 18, 19, and 20	46 19 29.8	96 52 49.0
Ts. 134 and 135 N., R. 49 W., corner secs. 31 and 32	46 16 53.7	96 52 50.0
Mooreton, railway crossing ½ mile west of	46 16 04.9	96 52 58.4
T. 132 N., Rs. 49 and 50 W., corner secs. 18, 19, 24, and 13	46 14 21.0	96 52 59.0
Ts. 131 and 132 N., Rs. 49 and 50 W., corner of	46 11 44.3	96 53 01.1
T. 131 N., Rs. 49 and 50 W., corner secs. 18, 19, 24, and 13	46 09 07.8	96 53 00.7
Ts. 130 and 131 N., Rs. 49 and 50 W., corner of	46 06 31.9	96 53 02.9
Hankinson, crossing range line and Chicago, Milwaukee and St. Paul Railway, east of	46 04 15.9	96 53 04.6

Geographic positions along the "Soo Line" between Hankinson and Fairmount.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Road crossing north and south	46 03 47.2	96 49 22.0
Road crossing north and south	46 03 29.3	96 45 36.9
T. 130 N., R. 48 W., ¼ corner between secs. 20 and 21	46 03 28.8	96 43 06.0
T. 130 N., R. 48 W., ¼ corner between secs. 23 and 24	46 03 27.8	96 39 21.9
T. 130 N., Rs. 47 and 48 W., ¼ corner sec. between 19 and 24	46 03 27.5	96 38 07.4
Fairmount, crossing of Chicago, Milwaukee and St. Paul Railway	46 03 27.0	96 36 15.3

Geographic positions along the Chicago, Milwaukee, and St. Paul Railway, between Fairmount and Wahpeton.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Fairmount, crossing of the Great Northern and Chicago, Milwaukee and St. Paul railways	46	03	53.1	96	36	15.3
Ts. 130 and 131 N., R. 47 W., ¼ corner between secs. 5 and 32	46	06	28.8	96	36	14.4
Tyler, railway crossing at	46	08	53.1	96	36	13.4
Ts. 131 and 132 N., R. 47 W., corner secs. 19, 20, 29, 30	46	13	26.8	96	36	49.1
Wahpeton, crossing Northern Pacific Railway	46	15	29.7	96	36	42.8
Wahpeton, crossing Great Northern Railway	46	15	43.7	96	36	42.8
T. 132 N., R. 47 W., north corner secs. 5 and 6	46	16	53.5	96	36	48.1
Wahpeton, crossing Great Northern Railway, north of	46	18	56.3	96	37	47.1
Brushville, ¼ sec. corner at	46	22	07.2	96	38	29.0

Geographic positions along the Great Northern Railway.

Station.	Latitude.			Longitude.		
MINNESOTA.	°	′	″	°	′	″
School house, railway crossing at	46	24	17.9	96	39	47.2
Kent station	46	26	10.4	96	40	54.4
Township line, east and west crossing on	46	27	19.7	96	41	35.9
T. 135 N., R. 48 W., corner secs. 15, 16, 21, and 22	46	29	55.8	96	43	01.7
Road crossing east and west	46	30	47.7	96	42	56.1

ROCKY MOUNTAIN SECTION OF TOPOGRAPHY.

E. M. DOUGLAS, *Geographer in charge.*

COLORADO-WYOMING.

TRIANGULATION STATIONS.

In the fall of 1902 Mr. R. H. Chapman extended triangulation northward from stations Cleveland, Harrison, and Hogback west of Greeley, Colo., to stations County Road, Lindsey, and Quartzite, near Laramie, Wyo. Besides reoccupying these six stations he monumented and occupied eleven new stations and located sixteen points by intersections. Positions are given on the U. S. standard datum as derived from Morrison-Table Mound stations in the transcontinental triangulation of the Coast and Geodetic Survey near Denver.

COLORADO-WYOMING LINE.

About 1½ miles west of south from Terry triangulation station and about one-half mile southeast from "Terry ranch," the home ranch of the Warren Live Stock Company, about 12 miles south from Cheyenne, Wyo., on Denver pike.

Station mark: Dressed red sandstone post marked "44 M" on east, "Wyoming" on north, "41° N. L. 1873 yards" on west, "Colorado" on south.

[Latitude 41° 00′ 21.38″. Longitude 104° 53′ 11.15″.]

To station	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Maxwell	67 39 31	247 26 40	4.47414
Terry	207 42 56	27 43 29	3.39986

Colorado.

FORT COLLINS, LARIMER COUNTY.

Station mark: Center of tower of court-house.

[Latitude 40° 35′ 11.64″. Longitude 105° 04′ 45.30″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Horsetooth	62 19 28.8	242 14 55.1	4.04865
Pizen	232 27 44.3	52 33 12.9	4.17453

HORSETOOTH, LARIMER COUNTY.

A high, bare, rocky point on divide immediately east of Redstone Creek, about 3 miles northeast of Masonville and about 8 miles south of west from Fort Collins. It is best reached from Fort Collins by taking the Masonville road and diverging from it at a point a little west from where the road passes the southeast ridge of the peak, and taking a trail, visible from the road, up the above ridge.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 40° 32′ 23 00″. Longitude 105° 11′ 46.21″.]

To station	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Harrison	300 30 20.72	120 44 23.09	4.5507671
Cleveland	333 17 51.90	153 29 08.64	4.7414387
Livermore	161 31 44.63	341 28 00.49	4.4061105
Pizen	236 36 22.09	56 46 24.43	4.4155868
Maxwell	177 55 51.51	357 55 10.83	4.6066170
Hogback	000 06 45.57	180 06 43.76	4.5275527

LIVERMORE, LARIMER COUNTY.

On highest point of a rocky mountain, about 3 miles southwest of Livermore post-office. It is between Lone Pine Creek and Main North Fork of Cache la Poudre River. It is about 4 miles north of "Grey Rock," a bare peak with cliff on east, south, and west. Horses ridden to station. Easily reached via long ridge southwest from Livermore post-office via Griffith's ranch.

Station mark: A bronze tablet cemented in solid rock.

[Latitude 40° 45′ 26.18″. Longitude 105° 17′ 30.29″.]

To station	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Horsetooth	341 28 00.49	161 31 44.63	4.4061105
Pizen	288 11 30.05	108 25 18.16	4.4967751
East Twin	183 37 55.88	3 38 53.41	4.5103976
Gale	141 56 35.40	321 44 53.11	4.6089354
Maxwell	202 05 53.64	22 08 57.83	4.2437306

MAXWELL, LARIMER COUNTY.

On southern end of a timbered ridge, about 7 miles northeast of Forks post-office, about 3 miles northeast of Steamboat Rock, and about 2.5 miles south of east of Fred. Maxwell's ranch, at east foot of

Red Mountain. The summit is gray limestone which shows as a continuous cliff about 20 feet high on west face of ridge.

Station mark: A bronze tablet cemented in solid white limestone.

[Latitude 40° 54′ 12.57″. Longitude 105° 12′ 48.56″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pizen	318 19 11.41	138 29 56.71	4.5427375
Horsetooth	357 55 10.83	177 55 51.51	4.6066170
Terry	244 32 04.96	64 45 29.64	4.5018860
Gale	116 31 23.84	296 16 35.78	4.5484084
East Twin	164 16 53.35	344 14 46.23	4.2230452
Livermore	22 08 57.83	202 05 53.64	4.2437306

PIZEN, LARIMER COUNTY.

About 10 miles northeast of Fort Collins, on a high, open prairie; edge of bluff overlooking valley of Cache la Poudre River. On highest point in that vicinity, about 3 miles north of "Pizen Hole" and 1 mile south and 2.5 miles east of Fred Herdig's ranch.

Station mark: An iron bench-mark post set 45 inches in the ground.

[Latitude 40° 40′ 06.55″. Longitude 104° 56′ 20.72″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hogback	24 35 11.55	204 25 09.25	4.7221606
Horsetooth	56 46 24.43	236 36 22.09	4.4155868
Livermore	108 25 18.16	288 11 30.05	4.4967751
Maxwell	138 29 56.71	318 19 11.41	4.6066170
East Twin	146 50 14.06	326 37 20.99	4.7028818
Terry	188 01 26.95	8 04 03.62	4.6030505
Harrison	344 49 07.15	164 53 09.28	4.5259602

Wyoming.

COUNTY ROAD, ALBANY COUNTY.

About 6 miles from Laramie, 2½ miles north of a west line. It is about 25 feet north of road, between road and bluff. It is one-fourth mile east of stone at section corner marked ⊤ on south and ⊥ on east (southwest corner of sec. 16, T. 16 N., R. 74 W.), and three-fourths mile west of stone at section corner marked ⊥ on south (southeast corner of same section).

Station mark: A stone about 6 by 4 inches projecting about 3 inches *above surface,* with one-fourth inch hole one-half inch deep in center.

Reference mark: An iron bench-mark post set 36 inches in the ground, 18 inches east of station mark.

[Latitude 41° 21′ 00.63″. Longitude 105° 42′ 22.99″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Crow	300 17 28.18	120 27 56.95	4.4099220
Gale	343 50 57.49	163 55 34.19	4.5474458
Lindsey	348 18 20.37	168 21 00.06	4.4455330
Pilot	281 33 21.06	101 43 44.77	4.3365760
Quartzite	247 48 29.10	67 58 36.84	4.3481574

CROW, ALBANY COUNTY.

On a high, partly timbered summit, on ridge running nearly north and south, 10 miles southeast from Laramie, about 10 miles north of Ames monument at old Sherman, and about 10 miles north of Tie Siding. Old road running along crest of ridge passes 100 yards east of station, is reached by road north from Tie Siding via Aug. Borgerman's ranch. Station is three-fourths of a mile south of Laramie-Cheyenne road at Cheyenne Pass.

Station mark: A bench-mark tablet cemented in solid sandstone, stamped "8878 feet."

[Latitude 41° 13′ 59.35″. Longitude 105° 26′ 30.14″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gale	30 47 24.10	210 41 33.61	4.3857278
East Twin	324 26 33.40	144 33 26.38	4.4015676
Ragged	199 36 58.20	19 40 50.12	4.3852928
Pilot	174 02 33.18	354 02 07.68	3.9376136
County road	120 27 56.95	300 17 28.18	4.4099220
Lindsey	49 12 58.86	229 05 11.13	4.3403873

GALE, ALBANY COUNTY.

A prominent rocky peak, near north end of Boulder Ridge, about 1½ miles north of Colorado-Wyoming line. About 9 miles southwest of Tie Siding and 500 yards north of road from there to North Park, via Boulder Ridge. About 5 miles northwest of well-known rocky peak called "Diamond Peak."

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 41° 02′ 42.12″. Longitude 105° 35′ 22.88″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
County road	163 55 34.19	343 50 57.50	4.5474458
Crow	210 41 33.61	30 47 24.10	4.3857278
East Twin	269 07 00.78	89 19 42.82	4.4330476
Maxwell	296 16 35.78	116 31 23.84	4.5484084
Livermore	321 44 53.11	141 56 35.40	4.6089354

GREENTOP, ALBANY COUNTY.

(Not occupied.)

A secondary point on a timbered rocky peak, about 3 miles southwest from Horse triangulation station and about 5 miles south of Horse Creek.

Station mark: Highest point located.

[Latitude 41° 21′ 01.0″. Longitude 105° 19′ 48.8″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Crow	35 42 46	215 08 21	4.20444
Pilot	66 48 30	246 43 40	4.04666

HORSE, ALBANY COUNTY.

A low, rocky, bare butte between branches of Horse Creek, about 5 miles northeast of E. C. Lapash's ranch, and about 2 miles northeast of "Greentop," a timbered rocky butte known locally, and 2½ miles almost south of prominent rocky point, which looks like a beehive, known as "Ragged Top," and 2 miles southeast of "V K" ranch.

Station mark: A bronze tablet set in solid rock.

[Latitude 41° 23′ 06.97″. Longitude 105° 18′ 15.8″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Crow	34 17 10	214 11 53	4.31040
Ragged	150 54 32	330 52 57	3.83495

LINDSEY, ALBANY COUNTY.

On a butte of a long bare ridge, running north from high timbered *mesa, 20 miles* south of Laramie. About 4 miles southwest of McGib*bon ranch.*

Station mark: A bench-mark tablet with triangle cut in top cemented in block of rock about 14 by 12 by 10 inches, set level with surface and cemented in place.

[Latitude 41° 06′ 15.08″. Longitude 105° 38′ 20.68″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
County road	168 21 00.06	348 18 20.37	4.4455330
Crow	229 05 11.13	49 12 58.86	4.3403873

MOUND, ALBANY COUNTY.

Bare grassy ridge 2 miles southwest of Twin Peak, 10 miles south of Sherman.

Station mark: Highest point.

[Latitude 41° 00′ 20.42″. Longitude 105° 17′ 33.74″.]

To station	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gale	100 01 25.4	279 49 43.6	4.40411
Livermore	359 49 51.1	179 49 53.4	4.44068

PILOT, ALBANY COUNTY.

On highest point of long high ridge east of Laramie, from which it appears as timbered; about 5 miles north of Cheyenne Pass; accessible to wagon from there or from road, crossing ridge one-half mile north of station. About 1 mile southwest of Big Indian Spring.

Station mark: A bronze bench-mark tablet cemented in solid rock 6 inches beneath surface, over which is a loose cairn 1 foot high.

[Latitude 41° 18′ 38.61″. Longitude 105° 27′ 08.79″.]

To station	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
County road	101 43 44.77	281 33 21.06	4.3365760
Quartzite	177 22 19.72	357 22 03.06	4.1066498
Ragged	212 24 01.44	32 28 19.09	4.2275853
Crow	354 02 07.68	174 02 33.18	3.9376136

QUARTZITE, ALBANY COUNTY.

On a high ridge 10 miles northeast of Laramie, about 1½ miles south of main wagon-road crossing.

Station mark: A bench-mark tablet cemented in solid rock at point where + was cut in 1892.

[Latitude 41° 25′ 32.55″. Longitude 105° 27′ 34.03″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
County road	67 58 36.84	247 48 49.10	4.3481574
Ragged	261 12 35.86	81 17 10.49	3.9889947
Pilot	357 22 03.06	177 22 19.72	4.1066498

RAGGED, ALBANY COUNTY.

On highest rock of group of pinnacles about 3 miles north of "V K" ranch on Horse Creek, locally known as "Ragged Top."

Station mark: A bench-mark tablet in solid rock, with triangle cut in top.

[Latitude 41° 26′ 20.64″. Longitude 105° 20′ 39.00″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Crow	19 40 50.12	199 36 58.20	4.3852928
East Twin	351 31 58.06	171 35 00.39	4.6421429
Pilot	32 28 19.09	212 24 01.44	4.2275853
Quartzite	81 17 10.49	261 12 35.86	3.9889947

"ROCK S. E." ALBANY COUNTY.

(Not occupied.)

A secondary point on easternmost rocky butte, about 3 miles south of Pole Creek and 3 miles east of Pole Mountain.

Station mark: Highest point of rock.

[Latitude 41° 14′ 12.6″. Longitude 105° 19′ 03.9″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pilot	126 04 26	305 59 06	4.14474
Ragged	174 23 08	354 22 06	4.35355

EAST TWIN, LARAMIE COUNTY.

Easternmost and higher of two rocky peaks known as "Twin Mountains," about 10 miles southeast of Sherman and 20 miles a little south of west from Cheyenne. Easily ascended by saddle horses.

Station mark: A bronze tablet cemented in flat surface of solid rock.

[Latitude 41° 02′ 54.04″. Longitude 105° 16′ 02.43″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Livermore	3 38 53.41	183 37 55.88	4.5103976
Pizen	326 37 20.99	146 50 14.06	4.7028818
Crow	144 33 26.38	324 26 33.40	4.4015676
Ragged	171 35 00.39	351 31 58.06	4.6421429
Maxwell	344 14 46.23	164 16 53.35	4.2230452
Terry	274 08 12.42	94 24 45.54	4.5223308
Gale	89 19 42.82	269 07 00.78	4.4330476

TERRY, LARAMIE COUNTY, WYO.

A round, conical, bare hill about 10 miles south of Cheyenne; about 2 miles northeast of old "Terry Ranch," now "Home Ranch" of Warren L. S Co.; about 1½ miles east of Cheyenne-Fort Collins road.

Station mark: An iron bench-mark post set 3 feet in ground around which is a small mound of rock.

[Latitude 41° 01′ 33.44″. Longitude 104° 52′ 21.17″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pizen	8 04 03.62	188 01 26.95	4.6030505
Maxwell	64 45 29.64	244 32 04.96	4.5018860
East Twin	94 24 45.54	274 08 12.42	4.5223308

ARIZONA.

TRIANGULATION STATIONS.

Mr. H. L. Baldwin, topographer, was engaged in March and April, 1902, in extending triangulation northward from the base New River-Union for the purpose of furnishing control for the survey of the Grand Canyon Forest Reserve.

He established and marked the position of 18 primary stations which control 7 thirty-minute quadrangles and 5 secondary stations which control the Jerome special quadrangle, observing for azimuth at two stations.

BISSEL, COCONINO COUNTY.

About 7 miles northeast of Grand View Hotel; reached by wagon road. Lines of sight were cleared to San Francisco Mountain and Kendrick.

Station mark: A bronze B. M. tablet set in solid rock.

[Latitude 36° 00′ 52.00″. Longitude 111° 54′ 45.20″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kendrick	355 17 40	175 19 44	4.830226
Middle	107 17 06	287 11 02	4.20968
Point Sublime	123 43 47	303 31 49	4.56358

FLOYD, COCONINO COUNTY.

On summit of mountain of that name, 10 miles northeast of Seligman.

Station mark: A rock cairn 8 feet base and 10 feet high, built by the Powell Survey in 1872.

Reference mark: A bronze tablet set in a large bowlder. True azimuth from monument, 290° 23′; distance, 12 feet.

[Latitude 35° 23′ 29.88″. Longitude 112° 43′ 29.30″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Picacho	4 45 03.24	184 44 28.91	4.2584423
Rowe	214 10 05.72	34 30 04.66	4.9612843
Red Butte	230 17 27.69	50 39 37.68	4.8724051
Middle	217 54 56.04	38 17 22.48	4.9727543
Williams	294 12 18.34	114 30 18.21	4.7146324

KENDRICK, COCONINO COUNTY.

On summit of Mount Kendrick.

Station mark: A bronze tablet set in solid Malapai rock, over which was erected a signal of rocks and pine boughs, 10 feet base and 8 feet high.

[Latitude 35° 24′ 24.83″. Longitude 111° 51′ 05.35″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Picacho	76 31 55.77	256 01 03.88	4.9206164
Williams	54 29 31.81	234 17 15.00	4.5979301
Red Butte	154 45 37.08	334 37 16.56	4.7041812

MIDDLE, COCONINO COUNTY.

Station is located on the northwest point of the prominent headland *about 3 miles east* of the Bright Angel Hotel.

Station mark: A bronze tablet set in the flat limestone ledge.

Reference mark: A small pine tree. True azimuth from tablet, 223° 40′; distance, 6.17 feet.

[Latitude 36° 03′ 27.91″. Longitude 112° 05′ 03.37″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Red Butte	1 10 12.23	181 09 49.60	4.4227904
Williams	6 37 05.06	186 32 50.51	4.9818901
Floyd	38 17 22.48	217 54 56.04	4.9727543
Rowe	104 26 01.86	284 23 32.93	3.8153410

RED BUTTE, COCONINO COUNTY.

On the highest point of well-known mountain of that name.

Station mark: A bronze tablet set in a malapai rock.

[Latitude 35° 49′ 09.18″. Longitude 112° 05′ 24.90″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Williams	8 41 01.11	188 36 59.81	4.8426625
Floyd	50 39 37.68	230 17 27.69	4.8724051
Rowe	168 21 10.24	348 18 54.38	4.4576742
Middle	181 09 49.60	1 10 12.23	4.4227904
Kendrick	334 37 16.56	154 45 37.08	4.7041812

ROWE, COCONINO COUNTY.

On the headland of that name, 1.5 miles by road northwest from the Bright Angel Hotel.

Station mark: A bronze tablet set in solid limestone ledge, 1.5 feet below surface of ground and nearly below the center of a Piñon stump 10 feet high, which served as a support for the instrument.

[Latitude 36° 04′ 20.70″. Longitude 112° 09′ 16.34″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Williams	2 44 59.69	182 43 12.48	4.9868657
Floyd	34 30 04.66	214 10 05.72	4.9612843
Middle	284 23 32.93	104 26 01.86	3.8153410
Red Butte	348 18 54.38	168 21 10.24	4.4576742

WILLIAMS, COCONINO COUNTY.

On Bill Williams Mountain, 4 miles south of the town of Williams.

Station mark: A bronze tablet set in solid rock projecting 2 feet above ground.

Reference mark: A rock cairn 7 feet high. True azimuth, 305° 04′; distance, 7.4 feet.

[Latitude 35° 11′ 56.22″. Longitude 112° 12′ 20.34″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Granite	27 07 31.70	206 55 34.32	4.8451720
Simmons	40 08 43.42	219 56 08.29	4.7147958
Picacho	94 02 01.04	273 43 29.09	4.6891695
Floyd	114 30 18.21	294 12 18.34	4.7146324
Rowe	182 43 12.48	2 44 59.69	4.9868657
Red Butte	188 36 59.81	8 41 01.12	4.8426625
Middle	186 32 50.51	6 37 05.06	4.9818901
Kendrick	234 17 15.00	54 29 31.81	4.5979301
Bald	343 45 02.15	163 54 01.08	4.9349310

AZIMUTH, GILA COUNTY.

On the low, grassy divideb etween Salt and Gila rivers drainage, about 2 miles southeast of Globe, one-fourth mile south of the wagon road crossing of the Globe, Gila Valley and Northern Railroad on the above divide.

Station mark: A bronze tablet cemented in solid rock and centered under a rock monument.

[Latitude 33° 22′ 04.59″. Longitude 110° 45′ 22.03″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pinal	[a] 41 36 27.02	221 33 48.00	4.0521882
	[b] 41 36 33.07	221 33 54.05	
Black Hawk	[a] 172 08 56.68	352 08 34.49	3.8812944
	[b] 172 09 02.73	352 08 40.54	

[a] Computed from Maricopa. [b] Observed.

BLAIR, GILA COUNTY.

(Apache Indian Reservation.)

On the highest point of a long ridge, bluffy on the north end, 15 miles southeast of Globe, 10 miles south and a little west of Gilson water tank on the Globe, Gila Valley and Northern Railroad.

Station mark: A bronze tablet cemented in solid rock and centered under a rock monument.

[Latitude 33° 15′ 10.23″. Longitude 110° 38′ 15.43″.]

To station—	Azimuth.	Back azimuth.	Log distance.
	° ′ ″	° ′ ″	*Meters.*
Pioneer	61 44 28.00	241 40 32.70	4.1013236
Pinal	103 12 31.42	283 05 58.60	4.2794265
Black Hawk	149 18 03.02	329 13 46.42	4.3732750
Coal	341 58 15.25	162 00 16.86	4.2700257

COAL, GILA COUNTY.

On the summit of the limestone divide between Gila River and Deer Creek, 3 miles northeast of the lower coal fields, 18 miles northeast of Dudleyville, and about 15 miles southeast of San Carlos, 6 miles north of Manningo ranch on Deer Creek. An old Indian trail from Dudleyville to San Carlos crosses the ridge one-fourth mile west of station.

Station mark: A nail cemented in a hole drilled in solid rock, centered under a rock monument.

[Latitude 33° 05′ 35.38″. Longitude 110° 34′ 33.18″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Ripsey	73 12 40.39	252 59 50.83	4.5829189
Kelvin	101 51 23.83	281 39 54.91	4.5235581
Pioneer	124 49 01.79	304 43 05.47	4.3130220
Black Hawk	154 55 01.46	334 48 43.50	4.6231189
Blair	162 00 16.86	341 58 15.25	4.2700257
Triplets	217 11 30.46	37 18 55.33	4.5408219
Gila	259 07 57.83	79 28 24.66	4.7722287
Turnbull	274 21 23.30	94 31 40.94	4.4688635

KELVIN, GILA COUNTY.

On the highest round hill on the divide between Gila River, Mineral and Dripping Spring creeks, 3 miles east of the Ray mine on Mineral Creek, 2 miles west of the Gray mining camp on the Globe-Riverside wagon road where it crosses the divide 8 miles north of Riverside.

Station mark: Three nails cemented in a hole drilled in the solid rock, over which is centered a rock monument.

[Latitude 33° 09′ 16.27″. Longitude 110° 55′ 34.00″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Ripsey	12 18 20.80	192 16 58.59	4.2636308
Grayback	61 29 58.57	241 24 12.47	4.2640522
Kings Crown	145 13 11.80	325 08 18.55	4.3756044
Pinal	208 42 30.15	28 45 26.88	4.2399056
Pioneer	252 38 26.06	72 43 59.40	4.2182857
Coal	281 39 54.91	101 51 23.83	4.5235581

PIONEER, GILA COUNTY.

On the highest point of a black ridge, with a bluff on its north end, about 5 miles east of the old Pioneer mining camp (stage station) on the Globe and Riverside wagon road.

Station mark: A hole drilled in a large bowlder, above which is built a rock monument 6 feet high.

[Latitude 33° 11′ 55.96″. Longitude 110° 45′ 24.86″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Ripsey	40 49 45.04	220 42 50.17	4.4795748
Kelvin	72 43 59.40	252 38 26.06	4.2182857
Kings Crown	116 31 03.98	296 20 36.53	4.5151398
Black Hawk	177 53 43.95	357 53 23.41	4.4200375
Blair	241 40 32.72	61 44 28.00	4.1013235
Coal	304 43 05.47	124 49 01.79	4.3130220
Pinal	144 17 52.01	324 15 14.90	4.1040238

PINNACLE, MOHAVE COUNTY.

(Not occupied.)

[Latitude 36° 09′ 05.58″. Longitude 112° 05′ 57.14″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Middle	352 38 00	172 38 28	4.02094
Rowe	29 35 14	209 33 17	4.00413

POINT SUBLIME, MOHAVE COUNTY.

(Not occupied.)

On point of same name on north side of Grand Canyon.

Station mark: Evergreen tree about 15 feet high.

[Latitude 36° 11′ 49.94″. Longitude 112° 15′ 03.71″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bissel	303 31 49.00	123 43 47.00	4.56358
Middle	315 48 59.48	135 54 53.42	4.3336057
Floyd	25 44 25.98	205 27 48.40	4.9961237

SHIVAS, MOHAVE COUNTY.

(Not occupied.)

[Latitude 36° 08′ 24.00″. Longitude 112° 08′ 15.92″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Middle	332 09 30	152 11 23	4.01363
Rowe	11 24 03	191 23 27	3.88363

VISHNU TEMPLE, MOHAVE COUNTY.

(Unoccupied.)

Station mark: Center of rock spire.

[Latitude 36° 05′ 15.57″. Longitude 111° 56′ 10.02″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Middle	76 04 54	255 59 40	4.13838
Rowe	85 09 05	265 01 22	4.29549

RIPSEY, PINAL COUNTY.

On a high hill at the head of the Ripsey wash, 1 mile south of the old Ripsey mine, 12 miles south of Kelvin and Riverside.

Station mark: A hole drilled in a large bowlder, above which is built a large rock monument.

[Latitude 32° 59′ 34.28″. Longitude 110° 58′ 04.64″.]

To station	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gray Back	126 49 08.44	306 44 45.20	4.1842064
Kings Crown	165 32 33.80	345 29 03.58	4.5871790
Kelvin	192 16 58.59	12 18 20.80	4.2636308
Pioneer	220 42 50.17	40 49 45.04	4.4795748
Coal	252 59 50.83	73 12 40.39	4.5829189

AZIMUTH, YAVAPAI COUNTY.

On a small hill one-third mile south of Crookton station, on the Atchison, Topeka and Santa Fe Railroad.

Station mark: A 10-penny nail in the ground.

Azimuth mark: Small nail in window sill west of door in telegraph station.

[Latitude 35° 17′ 14.83″. Longitude 112° 42′ 28.30″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Picacho	25 03 33.82	205 02 24.33	3.8565762
Floyd	172 24 48.17	352 24 12.89	4.0667159

BALD MOUNTAIN, YAVAPAI COUNTY.

On mountain of that name, 10 miles southwest of Camp Verde.

Station mark: A bronze tablet set in malpais rock 2 by 3 feet and projecting 1 foot above ground.

Reference mark: A large juniper tree. True azimuth, 350° 53′; distance, 22.4 feet.

[Latitude 34° 27′ 13.17″. Longitude 111° 56′ 36.67″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
New River	7 04 02.86	187 01 56.84	4.6690657
Union	84 11 25.14	263 55 45.78	4.6298541
Granite	110 06 11.10	289 45 25.31	4.7751434
Carter	140 42 38.87	320 34 21.88	4.5465106
Williams	163 54 01.08	343 45 02.15	4.9349310

CAMP WOODS, YAVAPAI COUNTY.

About 15 miles west of Simmons post-office, on the Camp Woods road, on the eastern and lower of two prominent points of nearly equal height.

Station mark: A bronze tablet set in solid sandstone rock.

[Latitude 34° 50′ 02.61″. Longitude 112° 55′ 08.77″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Simmons	268 27 49.37	88 41 44.91	4.5029074
Granite	303 05 14.96	123 17 44.32	4.6018457
Kirkland	349 56 57.69	170 00 39.41	4.7575935
Picacho	200 14 51.58	20 22 59.01	4.6692858

CARTER, YAVAPAI COUNTY.

On the high bluff, 2 miles west of summit of Prescott and Jerome wagon road.

Station mark: A bronze triangulation tablet cemented in malpais rock.

[Latitude 34° 41′ 56.36″. Longitude 112° 11′ 12.40″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Union	32 24 12.30	212 16 46.75	4.5732755
Simmons	114 14 25.74	294 01 16.58	4.5861179
West Edge	190 37 56.51	10 38 19.56	3.7466252
Bald	320 34 21.88	140 42 38.87	4.5465106

EAST ANTELOPE, YAVAPAI COUNTY.

On highest peak, 4 miles east of Antelope Peak.

Station mark: A bronze tablet cemented in solid malpais rock, over which is erected a rock cairn 7 feet high and 6 feet base.

[Latitude 34° 13′ 10.71″. Longitude 112° 40′ 29.64″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kirkland			4.2352428
Del Pasco	266 56 26.10	87 06 46.69	4.4514305
Silver	292 12 38.31	112 21 39.55	4.4260126

ERROR, YAVAPAI COUNTY.

About one-half mile northwest of the summit of the abandoned Prescott and Jerome wagon road over Mingus Mesa.

Station mark: A bronze tablet cemented in solid rock.

Reference mark: A pine tree; lower branches trimmed off. True azimuth 333° 15′; distance, 7.7 feet.

[Latitude 34° 42′ 39.97″. Longitude 112° 09′ 23.94″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Carter	64 03 07	244 02 05	3.48713
East Edge	176 51 44	356 51 38	3.66890
Mineral	218 49 44	38 50 56	3.70736

EAST EDGE, YAVAPAI COUNTY.

On the east edge of the Mingus Mesa and overlooking the town of Jerome.

Station mark: A bronze B. M. tablet, set in solid ledge and surrounded by a small rock monument.

[Latitude 34° 45′ 11.16″. Longitude 112° 09′ 33.98″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
West Edge	70 37 48.79	250 37 15.76	3.193765
Carter	22 39 11.32	202 38 15.26	3.813154
Error	356 51 38.00	176 51 44.00	3.668903
Mineral	281 15 43.00	101 17 00.00	3.54646
Limestone	257 09 33.00	77 11 13.00	3.66052

FAITH, YAVAPAI COUNTY.

On highest peak of ridge south of where Hassayampa Creek enters the desert and 6 miles northeast of Wickenburg.

Station mark: A bronze B. M. tablet cemented in solid rock under center of a cairn 8 feet high.

[Latitude 34° 01′ 35.01″. Longitude 112° 45′ 15.02″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
East Antelope	187 10 19.90	7 11 19.02	4.3345530
Del Pasco	233 25 27.86	53 36 46.02	4.5856772

GRANITE, YAVAPAI COUNTY.

On mountain of that name 9 miles northwest of Prescott.

Station mark: A bronze tablet cemented in highest granite bowlder.

[Latitude 34° 38′ 12.34″. Longitude 112° 33′ 13.61″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Camp Woods	123 17 44.32	303 05 14.96	4.6018457
Simmons	175 59 11.71	355 58 36.04	4.3564571
Williams	206 55 34.32	27 07 31.70	4.8451720
West Edge	250 13 31.22	70 26 26.25	4.5659158
Bald	289 45 25.31	110 06 11.10	4.7751434
Union	331 02 01.74	151 07 05.35	4.4509915

KIRKLAND, YAVAPAI COUNTY.

On highest peak of Weaver Mountains, 10 miles southwest of the town of Kirkland.

Station mark: A bronze tablet cemented in solid rock at the summit.

[Latitude 34° 19′ 33.78″. Longitude 112° 48′ 38.11″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Camp Woods	170 00 39.41	349 56 57.69	4.7575935
Granite	214 19 02.74	34 27 46.14	4.6208307
Union	255 15 07.19	75 28 51.52	4.5861435
East Antelope			4.2352428

LIMESTONE, YAVAPAI COUNTY.

One-half mile north of the town of Jerome, on the north end of the limestone hill.

Station mark: A bronze tablet set in solid limestone ledge, over which is placed a small rock monument.

[Latitude 34° 45′ 44.11″. Longitude 112° 06′ 38.53″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mineral	30 41 13	210 40 50	3.29696
East Edge	77 11 13	257 09 33	3.66052
North Mingus	2 47 30	182 47 23	3.78025

MINERAL, YAVAPAI COUNTY.

Station is near a mineral monument on the high point one-fourth mile south of the town of Jerome.

Station mark: A bronze tablet set in the solid rock over which is erected a rock monument 3 feet high.

Reference mark: A mineral monument. True azimuth, 110° 45′; distance, 4.36 feet.

[Latitude 34° 44′ 48.82″. Longitude 112° 07′ 18.28″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Error	38 50 56	218 49 44	3.70736
East Edge	101 17 00	281 15 43	3.54646
Limestone	210 40 50	30 41 13	3.29696
North Mingus	350 34 59	170 35 15	3.64142

NORTH MINGUS, YAVAPAI COUNTY.

On the north end of the Mingus Mesa, 3 miles south of Jerome.

Station mark: A bronze tablet set in malpais rock.

[Latitude 34° 42′ 28.57″. Longitude 112° 06′ 50.14″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Carter	81 33 50.86	261 31 21.51	3.829173
West Edge	128 32 13.96	308 30 07.56	3.858072
Mineral	170 35 15.00	350 34 59.00	3.641420
Limestone	182 47 23.00	2 47 30.00	3.780250

PICACHO, YAVAPAI COUNTY.

On north end of Picacho Butte, 10 miles southeast of Seligman railroad station.

Station mark: A bronze tablet set in a large bowlder on the summit, over which a rock cairn 5-foot base and 6 feet high was erected.

[Latitude 35° 13′ 43.54″. Longitude 112° 44′ 28.69″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Floyd	184 44 28.91	4 45 03.24	4.2584423
Kendrick	256 01 03.88	76 31 55.77	4.9206164
Williams	273 43 29.09	94 02 01.03	4.6891695
Camp Woods	20 22 59.01	200 14 51.58	4.6692858

SIMMONS, YAVAPAI COUNTY.

On highest of the prominent hills 4 miles northeast of Simmons post-office.

Station mark: A bronze tablet set in solid granitic sandstone on summit.

[Latitude 34° 50′ 27.92″. Longitude 112° 34′ 16.20″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Camp Woods	88 41 44.91	268 27 49.37	4.5029074
Picacho	160 11 59.98	340 06 08.37	4.6601424
Williams	219 56 08.29	40 08 43.42	4.7147958
Carter	294 01 16.58	114 14 25.74	4.5861179
Granite	355 58 36.04	175 59 11.71	4.3564571

SOUTH MINGUS, YAVAPAI COUNTY.

On the south side of the Mingus Mesa, near east end.

Station mark: A pine tree, lower branches trimmed.

Reference mark: A bronze B. M. tablet cemented in malpais rock, bears approximately south, 20 feet distant.

[Latitude 34° 42′ 16.99″. Longitude 112° 06′ 48.70″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bald	330 41 51	150 47 38	4.504080
New River	352 21 11	172 24 50	4.874078

WEST EDGE, YAVAPAI COUNTY.

Near highest west edge of the volcanic mesa, 5 miles west of Jerome.

Station mark: A bronze tablet set in solid rock.

Reference mark: A large juniper tree. True azimuth, 138° 36′; distance, 16 feet.

[Latitude 34° 44′ 54.33.″ Longitude 112° 10′ 31.93″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Carter	10 38 19.36	190 37 56.51	3.7466252
Union	29 37 46.60	209 29 57.79	4.6300912
Granite	70 26 26.25	250 13 31.22	4.5659158

UTAH.

SECONDARY TRIANGULATION STATIONS.

Secondary triangulation for control of the Park City Special quadrangle was extended from primary stations Wanship and Clayton by Messrs. E. M. Douglas, geographer, and Pearson Chapman, topographer, in 1901–2.

Positions are given on the U. S. standard datum.

Geographic positions of principal mines at Park City.

Name of mine.	Point located.	Latitude.	Longitude.
		° ′ ″	° ′ ″
Ontario No. 2	Flag pole	40 37 23.05	111 29 36.86
Ontario No. 2	Hoisting rope	40 37 23.02	111 29 36.93
Silver King	Flag pole	40 37 51.89	111 30 46.24
Silver King	North shaft	40 37 51.88	111 30 46.22
Daly No. 2	Flag pole	40 37 15.03	111 30 20.96
Daly West	Flag pole	40 36 56.04	111 30 42.56
Daly West	Hoisting rope	40 36 56.08	111 30 42.58
Quincy	Hoisting rope	40 36 47.25	111 30 32.15
Anchor	Flag pole	40 36 46.91	111 31 12.10
Anchor	Hoisting rope	40 36 46.84	111 31 12.06

PACIFIC SECTION OF TOPOGRAPHY.

R. U. GOODE, *Geographer in charge.*

ARIZONA—CALIFORNIA.

TRIANGULATION STATIONS.

During the fall and winter of 1902–3, Mr. R. B. Robinson extended a system of quadrilaterals down the valley of the Colorado River from the vicinity of Needles, Cal., to Yuma, Ariz., a lineal distance of 175 miles. Forty stations were occupied and 24 located by intersections. This work depends upon stations in the expansion of the secondary base of the United States Coast and Geodetic Survey near Needles, and a check was obtained by connecting with stations Pilot and Azimuth of the United States and Mexican Boundary Survey Commission near Yuma. Positions are given on the United States standard datum as derived from the transcontinental belt of the Coast and Geodetic Survey through the secondary triangulation along the California-Nevada boundary line from Lake Tahoe to Needles. A few of the stations in the vicinity of Yuma were selected, built, and occupied by Mr. A. H. Sylvester, topographer, earlier in the season.

Arizona.

CONE, MOHAVE COUNTY.

A sharp, rocky peak, well known as "the Boundary Cone," about 17 miles northeast of Needles, Cal. The road to Kingman via the Snow Ball mine passes by the base of the peak. To go to Cone from Needles, take road to Snow Ball mine, past the Cone. Stop at the first big wash road crosses after passing the peak and go up the wash a short distance—the best and perhaps the only way up. Horses can not be taken much farther than the wash. There are several springs within 2 or 3 miles of the station and plenty of water at Leland mine, about 3 miles a little west of north.

Station mark: A bronze triangulation tablet wedged in solid rock, about 2 inches underground, under center of a cairn 7 feet high.

[Latitude 34° 59′ 01.39″. Longitude 114° 24′ 54.54″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sphinx	333 32 18.97	153 36 43.44	4.4215004
Knoll	49 51 22.25	229 44 04.98	4.4047806
Hill	69 08 44.90	248 59 57.08	4.3985648
Peak	95 48 47.00	275 39 14.25	4.4057480
Powell	356 11 33.97	176 12 24.71	4.5321828
Whale	19 26 32.62	199 22 08.57	4.5484345

FRIANT, MOHAVE COUNTY.

On one of the several rocky peaks about 2 miles from the Colorado River, at Pete McGuire's house on the California side of the river. Friant's place is 3 miles down the river from McGuire's. Station can easily be reached from either place. Signal can be seen from 50 yards below McGuire's house (it looks as if it were on the side of the hill from here). To go from McGuire's follow wash which leads up to the east side of peak, and take a ridge to the left.

Station mark: A bronze triangulation tablet cemented in rock even with top of ground.

[Latitude 34° 21′ 54.05″. Longitude 114° 10′ 11.29″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Axtel	75 51 30.71	255 43 21.63	4.3590878
Rocky	122 12 24.49	302 00 22.25	4.5850746
Red	153 20 23.47	333 16 55.78	4.3194664
Gier	347 45 54.63	167 47 03.53	4.1692339

MELLEN, MOHAVE COUNTY.

On the edge of mesa where it breaks off to the river, at Mellen Station, Ariz. The triangulation station is 135 steps north 85° west from Mellen railroad station, and 75 steps north 25° east from end of railroad bridge.

Station mark: A bronze triangulation tablet set in a solid round rock.

[Latitude 34° 43′ 03.63″. Longitude 114° 29′ 06.15″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Cone	192 12 01.12	12 14 24.90	4.47998
Hill	140 26 16.24	320 19 53.79	4.42657
Peak			4.57115

NO. 2, MOHAVE COUNTY.

On the highest part of white gravel and sand hills overlooking the Colorado River, about 300 yards east of the Mellen and Parker trail. Station is about 1 mile northeast of the Bill Wiles's place and is on the group of white hills to the north of a big wash which meets the river at this point.

Station mark: A rock 8 inches square on top set in ground with top a little above surface of ground and marked "U△S."

[Latitude 34° 32′ 29.63″. Longitude 114° 23′ 00.44″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Whale	136 58 01.92	316 52 34.53	4.33245
Powell	177 33 41.11	357 32 59.75	4.17850
Red			4.01257
Rocky			4.11280
No. 1			3.90156
No. 3			4.01711
No. 4			4.19184

PARKER SCHOOL, MOHAVE COUNTY.

(Not occupied.)

Station mark: Center of cupola.

[Latitude 34° 07′ 41.82″. Longitude 114° 18′ 35.08″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Low mesa	113 42 52.11	293 38 53.20	4.07574
Axtel	155 47 11.49	335 43 47.23	4.35494
Gier			4.29935
Black			3.96011

POWELL, MOHAVE COUNTY.

On a rocky peak about 4 miles south of Powell station, on the Santa Fe Railway, on the range of mountains of which the Needles form a part. It is the highest point on that range and is in view from Powell and Mellen. Station is easily reached from Powell by going up first big wash, leading south, east of Powell, but can be approached from any side. Horses can be taken to the base of peak.

Station mark: A bronze triangulation tablet cemented in rock under *center of cairn 8 feet* high.

[Latitude 34° 40′ 38.68″. Longitude 114° 23′ 25.71″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rocky	40 52 39.83	220 48 05.98	4.2737480
Whale	92 38 07.11	272 32 53.53	4.1474805
Knoll	129 06 00.24	308 57 54.01	4.4459924
Cone	176 12 24.71	356 11 33.97	4.5321828
Sphinx	222 33 25.62	42 36 58.47	4.1476673
Red	325 45 04.47	145 49 07.12	4.2869195

RED, MOHAVE COUNTY.

On the highest point of a group of foothills which lie at the base of the Chemehuevi Mountain on the west side. These hills are red, light red at the base and darker in color as they get higher. Station is about 7 miles east of the Bill Wiles place. A big wash leads from the Bill Wiles place to base of peak which signal is on. There is an old wagon road which can be followed all the way.

Station mark: A bronze triangulation tablet cemented in rock under center of cairn 9 feet high.

[Latitude 34° 31′ 59.11″. Longitude 114° 16′ 18.45″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Axtel	27 47 36.52	207 42 53.95	4.4378911
Rocky	94 30 40.52	274 22 04.91	4.3665687
Whale	123 48 34.19	303 39 18.51	4.4767442
Powell	145 49 07.12	325 45 04.47	4.2869195
Friant	333 16 55.78	153 20 23.47	4.3194664
Gier	339 15 11.73	159 19 48.13	4.5484957

SPHINX, MOHAVE COUNTY.

On a small rocky peak about 4 miles north 25° west from Franconia station, on Santa Fe Railway. It is the peak lying farthest south of a range of peaks at the foot of the higher mountains. To reach station go straight from anywhere along the railroad, traveling the washes or mesa as seems best.

Station mark: A bronze triangulation tablet wedged in solid rock about 2 inches under surface of ground. Rocks piled around each leg of tripod. There is also a cairn, marking a mining claim, on summit of the peak.

[Latitude 34° 46′ 14.37″. Longitude 114° 17′ 12.04″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Powell	42 36 58.47	222 33 25.62	4.1476673
Whale	67 38 58.68	247 30 11.86	4.4057412
Knoll	103 10 25.65	282 58 45.57	4.5052585
Hill	112 47 11.50	292 34 00.88	4.5810662
Peak	125 19 18.28	305 05 22.51	4.6571412
Cone	153 36 43.44	333 32 18.97	4.4215004

AGENCY, YUMA COUNTY.

About 14 miles south of Parker and 8 miles from the Colorado River at the nearest point. It is the farthest south peak of several making the range known by some people as the Hacawa Range. Station is not on the highest point, but lies about 3 miles west of the highest. The high water road down the river from Parker passes within 4 miles of station and from this road it is good traveling to the base of the peak.

Station mark: A bronze triangulation tablet cemented in rock and placed under center of a cairn 6 feet high.

[Latitude 33° 58′ 02.46″. Longitude 114° 18′ 54.48″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tyson	22 29 38.48	202 26 49.04	4.3103898
Marie	56 14 14.33	236 04 12.65	4.5236625
Riverside (2)	112 05 02.80	291 58 14.74	4.3053637
Low Mesa	155 19 12.74	335 15 25.58	4.3964387
Black	208 51 41.37	28 55 11.69	4.2990559

BLACK, YUMA COUNTY.

On the first high point about 5 miles east of Parker and close to the eastern corner of the Colorado River Indian Reservation. There are several small rock cairns on this peak, but there is no danger of signal being confounded with them, as it is 10 feet high. It is good traveling from Parker straight to foot of mountain and good foot traveling from there to summit.

Station mark: A bronze triangulation tablet cemented in a rock under center of a cairn 10 feet high.

[Latitude 34° 07′ 28.20″. Longitude 114° 12′ 39.47.″]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Agency	28 55 11.69	208 51 41.37	4.2990559
Riverside (2)	70 54 04.79	250 43 45.40	4.4769682
Low Mesa	104 37 42.07	284 30 23.58	4.3154911
Axtel	138 55 20.98	318 48 36.74	4.4467056
Gier	209 27 54.09	29 30 26.03	4.1483215

CHOCOLATE, YUMA COUNTY.

On a high, sharp peak of the Chocolate Mountains, overlooking the Colorado River Valley, about 200 yards south of the "Needles Eye." Both peaks are very prominent, and the "Needles Eye" shows plainly from the north or south. From the river, the best place to reach station is from Apache Island, about 1½ miles below No. 19 Station. Trails lead out from here to the main road running up and down the river. Follow the road up a short distance and take a right-hand road leading toward the mesa via Mrs. Hart's stamp mill. From this mill station bears 3° south of east and is about 6 miles off.

Station mark: A bronze triangulation tablet cemented in rock and placed under center of cairn 9 feet high.

[Latitude 33° 16′ 44.84″. Longitude 114° 33′ 46.63″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Clip	6 05 34.17	186 04 49.70	4.2976493
Lava	44 12 29.87	224 06 37.64	4.3786581
Fort Gass	105 38 19.19	285 31 16.39	4.3155582
Hodges	144 05 27.78	323 59 29.27	4.4575619
Mulewash	179 34 38.99	359 34 36.08	4.2677230

CLIP, YUMA COUNTY.

On a high peak on a range of hills lying about 8 miles a little east of north of Picacho, in sight of the water tanks of the Gold King Mining Company at Picacho. The best way to go to station is to take the road from Picacho to the Red Cloud Mine about north 65° east.

Station mark: A bronze triangulation tablet cemented in rock and placed under center of cairn 9 feet high.

[Latitude 33° 06′ 04.30″. Longitude 114° 35′ 07.86″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
American	30 02 27.81	209 57 00.53	4.4945347
Quartz	86 30 37.22	266 22 50.93	4.3461066
Lava	100 04 17.14	279 59 10.13	4.1701718
Fort Gass	144 51 15.20	324 44 57.89	4.4905956
Chocolate	186 04 49.70	6 05 34.17	4.2976493
Ridge	354 46 43.66	174 47 27.17	4.3582402

EHRENBERG, YUMA COUNTY.

On a flat sand and gravel mesa on the north bank of Weaver Wash, which runs into the Colorado River, about one-fourth mile above Ehrenberg. Station is about 2½ miles east of Ehrenberg, and can be reached by taking road up the river from Ehrenberg until it crosses Weaver Wash. Leave road and follow the wash about 2 miles. Station is on top of mesa on north side of wash about 20 steps from edge of bluff.

Station mark: A bronze triangulation tablet cemented in rock and placed in ground level with surface.

[Latitude 33° 36′ 11.17″. Longitude 114° 29′ 25.24″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mulewash	21 35 18.38	201 32 51.10	4.2723120
Hodges	61 42 01.87	241 33 37.38	4.4276039
Blythe	97 53 48.26	277 47 24.38	4.2563456
Marie	152 07 15.33	332 03 06.48	4.3921984
Tyson	201 20 19.79	21 23 21.13	4.3636828

GIER, YUMA COUNTY.

About 2 miles from Mrs. Gier's place on the Colorado River. It is south 51° east from Gier's, and 3 miles north 38° east from Brown's house at Empire Flat, on a high, mesa-topped peak, and is in plain view from the river in this vicinity.

Station mark: A bronze triangulation tablet cemented in a rock buried in ground under center of a cairn 10 feet high.

[Latitude 34° 14′ 05.72″. Longitude 114° 08′ 09.03″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Agency	29 11 13.94	209 05 12.06	4.5312160
Black	29 30 26.03	209 27 54.09	4.1483215
Riverside (2)	58 00 22.69	237 47 31.02	4.6190262
Low Mesa	75 24 47.37	255 14 56.23	4.4445210
Axtel	109 17 23.90	289 08 06.78	4.4281081
Rocky	134 24 51.99	314 11 41.88	4.6983570
Red	159 19 48.13	339 15 11.73	4.5484957
Friant	167 47 03.53	347 45 54.63	4.1692339

NO. 13, YUMA COUNTY.

About 2½ miles north 63° east from Ehrenberg post-office on top of a flat sand mesa, about one-half mile from Colorado River and about the same distance from the wagon road from Ehrenberg to Parkers Station, overlooks the river. Take the Parker wagon road from Ehrenberg and follow it 2 miles, then turn at right angles and go about one-half mile, and station will be found on the point of sand mesa where it breaks off to the river bottom.

Station mark: A bronze triangulation tablet cemented in a rock and placed in ground level with surface.

[Latitude 33° 36′ 58.40″. Longitude 114° 29′ 53.97″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Marie	152 03 10.83	331 59 17.87	4.36247
Tyson	204 30 15.73	24 33 33.04	4.34345
Blythe			4.23459
Ehrenberg			3.21279

NO. 14, YUMA COUNTY.

(Not occupied.)

On the edge of a white bluff, close to the Colorado River, about 5 miles below Ehrenberg, being the first place below Ehrenberg where the river washes the bluff.

Station mark: A bronze triangulation tablet cemented in a rock and placed in ground level with surface.

[Latitude 33° 32′ 22.76″. Longitude 114° 32′ 03.56″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Blythe	124 35 06.88	304 30 10.88	4.22410
Ehrenberg	210 06 45.51	30 08 13.06	3.91042
Hodges			4.30722

NO. 15, YUMA COUNTY.

(Not occupied.)

On the edge of a white bluff, about 15 miles below Ehrenberg, and is the second bluff which comes close to water of Colorado River below Ehrenberg. The river strikes this bluff about 1 mile above station and keeps close to bluff, with here and there a narrow strip of bottom between bluff and water, until at the point station is on bluff recedes from the river and river bottom begins to widen. There is about 60 or 70 yards of bottom between river and bluff, which signal is on. The road from Ehrenberg down the river passes about 2 miles east of station.

Station mark: A bronze triangulation cemented in rock and placed in ground level with surface under center of signal.

[Latitude 33° 28′ 44.37″. Longitude 114° 36′ 01.27″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hodges	94 31 26.51	274 26 41.34	4.12665
Mulewash	317 28 58.40	137 30 09.72	2.69402
Ehrenberg			4.23409
Blythe			4.25407

NO. 16, YUMA COUNTY.

(Not occupied.)

On point of bluff where mesa breaks off to the Colorado River, about 20 miles below Ehrenberg, and is 300 yards from water's edge. The road from Ehrenberg to Picacho, on the Arizona side of river, passes between the river and station and is about 200 yards distant at the nearest point. The bluff on which station is located overlooks a big wash and forms the south bank of it. This is the same wash which passes on the south side of Mulewash station and is the first big wash the road crosses below Mulewash.

Station mark: A bronze triangulation tablet cemented in rock and placed in ground level with surface.

[Latitude 33° 25′ 51.55″. Longitude 114° 37′ 28.36″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hodges	119 53 14.53	299 49 17.55	4.10715
Mulewash	253 15 27.14	73 17 26.41	3.76625
Fort Gass			4.25812
Chocolate			4.25022
No. 17			4.10664
No. 18			4.13086

NO. 24, YUMA COUNTY.

(Not occupied.)

On a small peak about 1 mile south of Castle Dome Landing and three-fourths of a mile east of the river.

Station mark: A bronze triangulation tablet cemented in solid rock, above which is built a cairn 6 feet high.

[Latitude 32° 56′ 26.34″. Longitude 114° 27′ 45.98″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sugarloaf	7 20 25.05	187 19 40.57	4.22250
Ridge	62 25 43.23	242 22 26.50	4.02587
American			4.45700

RHO, YUMA COUNTY.

On the highest point of a small peak in a low range of hills just east of the Colorado River and north of the choke in the valley above Yuma. It is about 16 miles from Yuma and the wagon road from Yuma to Ehrenberg runs within a mile of it (to the west).

Station mark: A large stone was set into the ground and marked with a triangle and drill hole. Over this was built a cairn 6 feet high.

[Latitude 32° 51′ 56.90″. Longitude 114° 25′ 14.12″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sugarloaf	36 23 59.99	216 21 53.23	4.01086
Ridge	104 15 05.24	284 10 26.27	4.13925
Yuma Azimuth			4.40176

SUGARLOAF, YUMA COUNTY.

On a prominent rocky peak between the Colorado and Gila rivers about 14 miles northeast of Yuma. The wagon road from Yuma to Ehrenberg runs within a mile of it. It has a hard capping overlying softer rock, hence its upper hundred feet approaches the perpendicular, particularly on the river side. It is shaped like the sole of a boot and on some maps is called Boot Peak, but the older and more common name seems to be Laguna which it gets from a good-sized laguna lying just north of it. There is just barely room to set up a tripod on its top.

Station mark: A copper bolt set in the solid rock and stamped U. S. △ G. S. Over this was built a cairn 3 feet high.

[Latitude 32° 47′ 28.93″. Longitude 114° 29′ 07.93″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Yuma Azimuth	54 32 59.44	234 28 40.95	4.1839943
Pilot	75 01 33.12	254 53 04.41	4.4037670
American	106 22 49.75	286 14 08.73	4.4157937
Ridge	147 59 01.62	327 56 29.74	4.1376339

TYSON, YUMA COUNTY.

On a rocky peak, one of a range of low mountains which extend out into the Colorado River Valley or bottom land. It can be reached with horses from Riverside Landing by a trail, which goes around the thick growth of brush close to river, to a Mexican ranch. Signal bears south 25° east from Riverside Landing and south 76° east from triangulation station No. 11.

Station mark: A bronze triangulation tablet cemented in rock and placed under center of a cairn 8 feet high.

[Latitude 33° 47′ 49.54″. Longitude 114° 23′ 58.42″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Ehrenberg	21 23 21.13	201 20 19.79	4.3636828
Blythe	54 07 34.87	233 58 08.62	4.5112583
Marie	90 52 43.41	270 45 32.12	4.2998503
Riverside (2)	157 34 32.78	337 30 35.21	4.4568470
Agency	202 26 49.04	22 29 38.48	4.3103898

YUMA AZIMUTH, YUMA COUNTY.

Established by the United States and Mexican Boundary Survey on the highest point of a granite butte one-fourth mile south of Southern Pacific Railway yards at Yuma.

Station mark: A brick pier 15 inches square set in a foundation of concrete and extending 36 inches above ground, having an iron bolt set in center of top.

[Latitude 32° 42′ 41.07″; 32° 42′ 39.54″.[a] Longitude 114° 37′ 05.72″; 114° 37′ 07.44″.[a]]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pilot	100 48 27.64	280 44 17.76	4.0882718
American	142 10 39.78	322 06 18.04	4.3116694
Ridge	194 04 11.71	14 05 58.85	4.3251262
Sugarloaf	234 28 40.95	54 32 59.44	4.1839943

[a] Position on Yuma data of the United States and Mexican Boundary Survey Commission.

California.

NO. 7, COLORADO RIVER INDIAN RESERVATION.

(Not occupied.)

On a white bluff where the bluff comes close to the river the first time, about 3 miles by the river below Parker.

Station mark: A bronze triangulation tablet cemented in a rock and placed in ground level with surface.

[Latitude 34° 07′ 24.09″. Longitude 114° 22′ 08.74″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gier	240 00 55.75	60 08 47.49	4.39465
Black	269 27 30.87	89 32 50.22	4.16400
No. 6			4.06416
Low Mesa			3.88115
Agency			4.25547
Axtel			4.33319

NO. 8, COLORADO RIVER INDIAN RESERVATION.

(Not occupied.)

On a white bluff where the bluff comes close to the river the third time below Parker. Up the river from here about 2 miles the river divides, forming a long island. Station is at the lower end of this island, very little below where the two channels of the river join.

Station mark: A bronze triangulation tablet cemented in rock placed in ground level with surface.

[Latitude 34° 04′ 08.03″. Longitude 114° 26′ 19.76″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Low Mesa	185 02 07.24	5 02 29.18	4.05739
Black	253 35 15.97	73 42 55.81	4.34071
Agency			4.20529
Riverside			3.96312

BLYTHE, RIVERSIDE COUNTY.

About 10 miles west of Ehrenberg post-office, on top of a flat sand mesa on a point as high as any about a mile from where the sand hills join the Colorado River bottom. To reach it from Ehrenberg take the road to Blythe's ranch until roads fork, then take left-hand road a short distance, then leave the road and go straight toward a flat-top peak, which shows to be toward the south end of the McCoy Mountains. Keep this direction until the valley is crossed and a flat sand mesa is reached. Signal is on this mesa and will show for several miles in any direction.

Station mark: A bronze triangulation tablet cemented in rock and placed in ground.

[Latitude 33° 37′ 31.10″. Longitude 114° 40′ 58.68″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hodges	20 28 13.68	200 26 12.35	4.2095854
Marie	198 02 39.26	18 04 55.21	4.3083779
Tyson	233 58 08.62	54 07 34.87	4.5112583
Ehrenberg	277 47 24.38	97 53 48.26	4.2563456
Mulewash	330 58 34.62	151 02 30.38	4.3563840

HODGES, RIVERSIDE COUNTY.

On the edge of bluff of sand mesa where mesa breaks off to the Colorado River bottom, which is wide at this point, and station is at least 6 miles from the river at the nearest point. Hodges mines bear north 62° west and are about 5 miles distant. A windmill in river flat and distant about 4 miles bears south 76° west.

Station mark: A bronze triangulation tablet placed in ground under center of signal.

[Latitude 33° 29′ 18.34″. Longitude 114° 44′ 38.17″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fort Gass	9 50 36.16	189 49 30.93	4.2534061
Blythe	200 26 12.35	20 28 13.68	4.2095854
Ehrenberg	241 33 37.38	61 42 01.87	4.4276039
Mulewash	285 39 03.74	105 45 00.12	4.2389082
Chocolate	323 59 29.27	144 05 27.78	4.4575619

MARIE, RIVERSIDE COUNTY.

On a high rocky peak of what is known as the "Marie Range" of mountains. It is not on the highest summit, but on a sharp, prominent peak overlooking the Colorado River Valley. Riverside Landing bears N. 27° E. from Marie and is about 15 miles off.

Station mark: A bronze triangulation tablet cemented in a rock placed under center of a cairn 9 feet high.

[Latitude 33° 47′ 58.79″. Longitude 114° 36′ 53.73″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Blythe	18 04 55.21	198 02 39.26	4.3083779
Riverside	198 54 24.01	18 57 39.06	4.4420501
Agency	236 04 12.65	56 14 14.33	4.5236625
Tyson	270 45 32.12	90 52 43.41	4.2998503
Ehrenberg	332 03 06.48	152 07 15.33	4.3921984

MULE WASH, YUMA COUNTY, ARIZ.

On top of flat gravel mesa, on south side of mule wash and about 4 miles from where sand wash joins the river. There is another big wash a little to south of station, which runs into river by station 16. Either of these washes lead close by station, but the upper one, or mule wash, is the smoothest. The road from Ehrenberg to Picacho, on the Arizona side of the Colorado River, passes within 2 miles of station. Where this road crosses mule wash, leave it and go up the wash about 2 miles to where wash forks—the right hand passes very close to station, but the left is probably the smoothest, and the divide between them is good traveling.

Station mark: A bronze triangulation tablet cemented in rock and placed in ground, with top about 3 inches above surface, under center of signal.

[Latitude 33° 26′ 46.08″. Longitude 114° 33′ 51.92″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fort Gass	56 47 15.95	236 40 15.12	4.3736406
Hodges	105 45 00.12	285 39 03.74	4.2389082
Blythe	151 02 30.38	330 58 34.62	4.3563840
Ehrenberg	201 32 51.10	21 35 18.38	4.2723120
Chocolate	359 34 36.08	179 34 38.99	4.2677230

NO. 9, RIVERSIDE COUNTY.

On a sand hill close to water's edge of Colorado River and about one-half mile up the river from Riverside Landing, a camp and subpost-office for the mines in the Riverside Mountains. A road runs close by station going from Riverside Landing up the river, a little below the south line of the Colorado River Indian Reservation.

Station mark: A bronze triangulation tablet cemented in a rock placed in ground level with surface.

[Latitude 33° 59′ 02.34″. Longitude 114° 29′ 52.52″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Agency	276 10 58.13	96 17 05.86	4.23025
Tyson	336 16 29.08	156 19 46.52	4.35484
Riverside			3.55098
Marie			4.36422

NO. 10, RIVERSIDE COUNTY.

On the point of a black rocky ridge which comes close to the Colorado River, about 5 miles below Riverside Landing. This is the first ridge of the kind after leaving that place. Station is very low down on the point of ridge closest to river and is about one-half mile from water's edge. There are at least two other small rock cairns on different parts of the ridge, but No. 10 is much lower down than they are. Station is in sight of the river for a considerable distance up and down and can be reached by a trail from Riverside Landing.

Station mark: A bronze triangulation tablet set in rock and placed under center of a cairn 8 feet high.

[Latitude 33° 54′ 51.11″. Longitude 114° 32′ 20.18″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
No. 9	206 05 04.16	26 06 26.63	3.93552
Agency	254 01 52.15	74 09 21.99	4.33273
Riverside			4.05230

NO. 11, RIVERSIDE COUNTY.

On edge of a low mesa, where it breaks off into the Colorado River bottom, about one-half mile from the water's edge at the nearest point, about 15 miles by the river from Riverside Landing and 20 miles above Ehrenberg. About 400 yards up the river from station the lower end of a big slough joins the river on the Arizona side.

Station mark: A bronze triangulation tablet cemented in rock placed in ground level with surface.

[Latitude 33° 49′ 21.70″. Longitude 114° 32′ 10.98″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Agency	231 50 30.41	51 57 54.57	4.41506
Tyson	282 35 38.28	102 40 12.37	4.11340
Riverside			4.32796
No. 10			4.00655
Marie			3.88686
No. 12			3.91457

NO. 12, RIVERSIDE COUNTY.

(Not occupied.)

On summit of a low rocky hill which comes close to the Colorado River, about 10 miles from Ehrenberg. There is a house close under this hill in the river bottom. Station is on point of the second rocky ridge which comes close to river below Riverside Landing and the first one above Ehrenberg and is about one-half mile from water's edge.

Station mark: A bronze triangulation tablet cemented in solid rock under center of a cairn 8 feet high.

[Latitude 33° 44′ 58.34″. Longitude 114° 31′ 21.30″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Marie	123 02 55.64	302 59 50.83	4.00867
Tyson	245 07 42.08	65 11 48.28	4.09889
No. 11			3.91457
Ehrenberg			4.21787

RIVERSIDE, RIVERSIDE COUNTY.

On a prominent peak of the Riverside Mountain range overlooking the Colorado River, though it is not the highest peak of the range, Riverside (2) triangulation station being on the highest peak, which lies north 15° west from here. The southwest corner of the Colorado River

Indian Reservation is close to station, which is about 4 miles north-northwest of Riverside Landing, or, as it is sometimes called, Walter's Camp. To go to station, camp at Riverside Landing and take road leading up the river to forks of road about 200 yards from the house, in a wash. Take left-hand road and follow it out until it becomes a trail, keep this trail about a mile and a half, where it stops at a prospect hole. From here keep up the ridge to the highest peak of this part of the range. Signal is not on quite the highest point, but is on a summit a hundred yards northeast of it.

Station mark: A bronze triangulation tablet set in a rock and placed under center of a cairn 9 feet high.

[Latitude 34° 00′ 48.72″. Longitude 114° 30′ 46.28″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Low Mesa	204 04 59.08	24 07 50.39	4.28290
Black	246 05 09.07	66 15 17.89	4.48380
No. 8			3.96312
Agency			4.27814
No. 9			3.55098

RIVERSIDE (2), RIVERSIDE COUNTY.

On the highest point of the Riverside Mountain range, close to the southwest corner of the Colorado River Indian Reservation, about 4 miles from the Colorado River at the nearest point.

Station mark: An aluminum bolt, marked U. S. G. S. △, set in a rock and placed in ground level with surface under center of a cairn 6 feet high.

[Latitude 34° 02′ 08.35″. Longitude 114° 31′ 04.18″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Marie	18 57 39.06	198 54 24.01	4.4420501
Low Mesa	208 49 12.80	28 52 14.59	4.2352388
Gier	237 47 31.02	58 00 22.69	4.6190262
Black	250 43 45.40	70 54 04.79	4.4769682
Agency	291 58 14.74	112 05 02.80	4.3053637
Tyson	337 30 35.21	157 34 32.78	4.4568470

AXTEL, SAN BERNARDINO COUNTY.

About 14 miles north 26° west from Parker Indian Agency and is on the highest point of the highest range in that part of the country.

Station mark: A bronze triangulation tablet cemented in rock under center of cairn 8 feet high.

[Latitude 34° 18′ 51.93″. Longitude 114° 24′ 38.30″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Low Mesa	5 44 48.78	185 44 13.70	4.2026604
Rocky	158 10 02.78	338 06 11.23	4.4483279
Red	207 42 53.95	27 47 36.52	4.4378911
Friant	255 43 21.63	75 51 30.71	4.3590878
Gier	289 08 06.78	109 17 23.90	4.4281081
Black	318 48 36.74	138 55 20.98	4.4467056

HILL, SAN BERNARDINO COUNTY.

A United States Coast and Geodetic Survey triangulation station 6 miles northwest of town of Needles and 2 miles west from the river, 2 miles northwest of ranch of Mr. Dinsmore on the highest of the hill just before going down into the first great wash after leaving the Dinsmore ranch.

Station mark: A bottle buried 2½ feet below the surface of ground, above which was placed a redwood stake 24 by 4 by 4 inches.

[Latitude 34° 54′ 11.20″. Longitude 114° 40′ 16.06″.]

To station	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Peak	170 20 03.6	350 19 19.4	4.0663630
Cone	248 59 57.08	69 08 44.90	4.3985648
Sphinx	292 34 00.88	112 47 11.50	4.5810662
Knoll	331 45 56.68	151 47 26.69	3.9272155

KNOLL, SAN BERNARDINO COUNTY.

A United States Coast and Geodetic Survey triangulation station about 1½ miles due west from the schoolhouse at the Needles, on a sharp, rounded peak or sand hill well covered with rocks.

Station mark: A bottle buried 2½ feet below surface of ground, above which was placed a large irregular mass of rocks, its top being 2 inches above surface of ground.

[Latitude 34° 50′ 09.38″. Longitude 114° 37′ 38.60″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hill	151 47 26.69	331 45 56.68	3.9272155
Peak	162 33 45.08	342 31 30.78	4.2977878
Cone	229 44 04.98	49 51 22.25	4.4047806
Sphinx	282 58 45.57	103 10 25.65	4.5052585
Powell	308 57 54.01	129 06 00.24	4.4459924
Whale	335 36 57.55	155 39 49.61	4.2696918

LOW MESA, SAN BERNARDINO COUNTY.

This station is not on any prominent point and is difficult to describe. The country for miles around it is much alike. The best way to reach it is to take the road from Parker to Needles and follow it until the 6-mile post is passed. About 200 yards beyond the 6-mile post the road goes over a high narrow backbone of mesa and down into a low wide stretch of wash country. From the road at this high place signal is in sight about 2 miles south, 66° west, on a white mesa ridge, with a long black hill in the distance for a background. Get the direction from this place, then follow the road a little farther, then leave it to the right and go straight across low flats and washes until the main wash is crossed close under station.

Station mark: A bronze triangulation tablet set in a rock and placed in the ground level with surface.

[Latitude 34° 10′ 16.99″. Longitude 114° 25′ 40.65″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Riverside (2)	28 52 14.59	208 49 12.80	4.2352388
Axtel	185 44 13.70	5 44 48.78	4.2026604
Gier	255 14 56.23	75 24 47.37	4.4445210
Black	284 30 23.58	104 37 42.07	4.3154911
Agency	335 15 25.58	155 19 12.74	4.3964387

MONUMENT, SAN BERNARDINO COUNTY.

A high sharp rock column, the farthest north corner of the Colorado River Indian Reservation, in sight from anywhere in the Parker country, and is a well-known peak.

Station mark: Summit of sharp peak.

[Latitude 34° 16′ 51.54″. Longitude 114° 15′ 16.47″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Low Mesa	152 46 47.65	232 40 56.58	4.30266
Black	346 56 57.99	166 58 26.25	4.25083
Gier			4.08172
Black			4.25083

NO. 1, SAN BERNARDINO COUNTY.

(Not occupied.)

About 1 mile down the river from Mojave Rock. Going down the Colorado River after passing Mojave Rock the river makes a bend to the right, and runs toward a white honeycombed bluff; station is on the highest part of this bluff.

Station mark: A bronze triangulation tablet cemented in rock set in ground under center of signal.

[Latitude 34° 35′ 40.26″. Longitude 114° 26′ 31.86″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Whale	136 37 57.64	316 34 30.20	4.13128
Powell	207 15 38.39	27 17 24.19	4.01476
Red			4.23192
No. 2			3.90156

NO. 3, SAN BERNARDINO COUNTY.

Station is at the lower end of Chemehuevis Valley, on the highest point of the mesa, where it comes nearly to the water's edge, immediately below where a big wash joins the river from the southwest. The point which signal is on is not quite as high as the rest of the bluff, and it forms a small hill in itself, there being the big wash on the north side and a small wash on the south or southeast side. Station is in a well-known bend of the river where it bends to the south, then east, forming a half circle at the lower end of the valley.

Station mark: A bronze triangulation tablet cemented in rock flush with top of ground and a few rocks piled over it, with a pile of gravel and sand around each of the tripod legs.

[Latitude 34° 26′ 52.06″. Longitude 114° 22′ 58.73″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rocky	130 58 06.30	310 53 17.96	4.23528
Red	227 09 27.12	47 13 13.79	4.14370
Axtel			4.17642
No. 2			4.01711
No. 4			3.91477

NO. 4, SAN BERNARDINO COUNTY.

(Not occupied.)

About 300 yards from the water edge, on a black rocky hill across the river from what is known as the black mesa range of hills, and is about 2 miles up the river from Grennan's mill. The range which station is on consists of a number of black hills and it is on the lowest one down the river of any consequence. There is a very red bluff across the river and a little below.

Station mark: A bronze triangulation tablet cemented in rock and set in loose rock level with surface of ground.

[Latitude 34° 25′ 09.73″. Longitude 114° 18′ 01.50″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rocky	125 04 48.06	304 57 11.53	4.40005
Red	191 46 01.55	11 46 59.88	4.11010
Friant			4.12839
Axtel			4.18857
No. 3			3.91477
No. 2			4.19184

NO. 5, SAN BERNARDINO COUNTY.

On a very rocky peak, the side next the river being a nearly perpendicular rock bluff several hundred feet high. It is about 1½ miles up the river from Mrs. Gier's place and about 2½ miles down from the mouth of the Bill Williams Fork. To reach station take the wash that joins the river just below the peak and follow it for one-half mile, then take a small wash to right for a hundred yards and go up ridge to right of it, which is rather steep for a short distance. Follow this ridge to station.

Station mark: A bronze triangulation tablet cemented in solid sandstone under center of a cairn 7 feet high.

[Latitude 34° 16′ 28.01″. Longitude 114° 08′ 25.36″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Black	21 22 56.28	201 20 33.45	4.25187
No. 6	47 29 53.48	227 25 43.61	4.18837
Gier			3.64386

NO. 6, SAN BERNARDINO COUNTY.

On a very rough, black little peak on the Colorado River, about one-half mile from the river, and is about three-fourths of a mile N. 30° E. from Headgate Rock, a rock bluff that comes to the water's edge on the Arizona side. Station is about 4 miles up the river from the pump house at Parker and is easily reached from the river.

Station mark: A bronze triangulation tablet set in solid rock, a small pile of rock around each leg of tripod.

[Latitude 34° 10′ 49.45″. Longitude 114° 15′ 49.59″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gier	242 48 37.37	62 52 56.68	4.12224
Black	321 50 13.12	141 51 59.85	3.89679
No. 5			4.18837
Axtel			4.30322
No. 7			4.06416

PEAK, SAN BERNARDINO COUNTY.

A United States Coast and Geodetic Survey triangulation station on the highest peak of the foot hills, 2 miles due west of Von Schmidt.

Station mark: A shallow hole drilled in top of a large irregular mass of hard rock set in ground.

[Latitude 35° 00′ 23.91″. Longitude 114° 41′ 33.21″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Cone	275 39 14.25	95 48 47.00	4.4057480
Sphinx	305 05 22.51	125 19 18.28	4.6571412
Knoll	342 31 30.78	162 33 45.08	4.2977878
Hill	350 19 19.40	170 20 03.60	4.0663630

ROCKY, SAN BERNARDINO COUNTY.

A very rocky peak on a high point of the Mojave range of mountains, about 6 miles southwest of Mojave Rock, a well-known rock on the east bank of the Colorado River, a little below where river leaves Needles Canyon. There is another signal of same description 2 miles northeast, on a lower point of same range. To go to Rocky, take a big wash which comes into river above Mojave Rock and follow it to foot of mountain. Good traveling for horses for some distance; no water except after rain. Station can be reached from anywhere along the river.

Station mark: A bronze triangulation tablet cemented under center of monument 9 feet high.

[Latitude 34° 32′ 57.54″. Longitude 114° 31′ 27.81″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Whale	173 15 06.19	353 14 26.99	4.1745934
Powell	220 48 05.98	40 52 39.83	4.2737480
Red	274 22 04.91	94 30 40.52	4.3665687
Friant	302 00 22.25	122 12 24.49	4.5850746
Gier	314 11 41.88	134 24 51.99	4.6983570
Axtel	338 06 11.23	158 10 02.78	4.4483279

WHALE, SAN BERNARDINO COUNTY.

On the highest point of a high, rocky range of mountains overlooking the Colorado River Valley, and can be seen from the river from Mellen up to Needles and beyond. It is about 6 miles south 65° east from Mellen station. To go there from Mellen, cross railway bridge and take up first big wash which crosses railway track. Stay in wash until a straight up-and-down bluff, 7 or 8 feet high, is passed. Go about one-half mile beyond here, then go up a spur to right, crossing no canyons until station is reached. Horses can not be taken this way.

Station mark: A bronze triangulation tablet cemented in solid rock, under a cairn 8 feet high.

[Latitude 34° 40′ 59.29″. Longitude 114° 32′ 36.82″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Knoll	155 39 49.61	335 36 57.55	4.2696918
Cone	199 22 08.57	19 26 32.62	4.5484345
Sphinx	247 30 11.86	67 38 58.68	4.4057412
Powell	272 32 53.53	92 38 07.11	4.1474805
Red	303 39 18.51	123 48 34.19	4.4767442
Rocky	353 14 26.99	173 15 06.19	4.1745934

AMERICAN, SAN DIEGO COUNTY.

On highest point of a range of mountains lying east of the American gold mine, and is about 3 miles a little south of east from the mine. Take road from Yuma to the American gold mine. Horses can be taken within a mile of station by following up wash from the mine.

Station mark: A bronze triangulation tablet cemented in rock and placed under center of cairn 8 feet high.

[Latitude 32° 51′ 26.38″. Longitude 114° 45′ 09.10″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Quartz	165 40 41.19	345 38 23.65	4.4231629
Clip	209 57 00.53	30 02 27.81	4.4945347
Ridge	256 13 38.72	76 19 48.46	4.2607025
Sugarloaf	286 14 08.73	106 22 49.75	4.4157937
Yuma Azimuth	322 06 18.04	142 10 39.78	4.3116694
Pilot	357 44 03.76	177 44 15.19	4.1430949

DELTA, SAN DIEGO COUNTY.

On a small bump near the east end of the black ridge bounding the Yuma Valley on the north, on the west or California side of the Colorado River. Reached from Fort Yuma, Cal., by wagon road to foot of ridge. Follow the Potholes road for 10 miles, more or less, then turn off across desert for one-half mile to foot of ridge. There is a 500-foot climb from where wagon is left to the station.

Station mark: A large bowlder marked with drill holes, triangles, and letters, thus: U S / G S Over the mark is built a cairn 6 feet high.

[Latitude 32° 50′ 34.39″. Longitude 114° 31′ 26.90″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
American	94 20 47.57	274 13 21.57	4.33122
Ridge	148 15 11.28	328 13 54.72	3.84313
Azimuth			4.23145
Sugarloaf			3.82999

FORT GASS, SAN DIEGO COUNTY.

On the summit of a very prominent rocky peak, about 3½ miles from the Colorado River at the nearest point, and the same distance from the wagon road from Ehrenberg to Picacho, on the California side of river. Station is about 30 miles up the river from Picacho,

and is west of the upper end of Apache Island. This is the most prominent peak in this part of the country, and is known by some as "Fort Gass" and others as "Milpitas."

Station mark: A bronze triangulation tablet cemented in rock under center of a cairn 8 feet high.

[Latitude 33° 19′ 45.13″. Longitude 114° 46′ 36.64″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Quartz	9 07 38.33	189 06 07.87	4.4314275
Hodges	189 49 30.93	9 50 36.16	4.2534061
Mulewash	236 40 15.12	56 47 15.95	4.3736406
Chocolate	285 31 16.39	105 38 19.19	4.3155582
Clip	324 44 57.89	144 51 15.20	4.4905956
Lava	351 45 55.50	171 47 04.97	4.3607200

HEDGES, SAN DIEGO COUNTY.

(Not occupied.)

On the highest point of a range of white mountains, about 15 miles northwest of Yuma, about 3 miles northeast of Hedges mine, and 3 miles a little west of north of American gold mine. A good road from Yuma to Hedges, and from latter place the station can be seen.

Station mark: An aluminum bolt cemented in rock under center of a cairn 8 feet high.

[Latitude 32° 53′ 32.32″. Longitude 114° 47′ 53.34″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Ridge	268 46 44.59	88 54 23.69	4.34195
American	312 14 49.78	132 16 18.93	3.76109
Clip			4.48460
Quartz			4.34067
Lava			4.41960
Pilot			4.26514
Azimuth			4.41828

LAVA, SAN DIEGO COUNTY.

On a high rocky peak about 4 miles from the Colorado River at the nearest point, and is south 59° west from Draper's Ranch, and can be seen from his house or the rock close by it. Take road from Picacho or Ehrenberg on California side of river which goes by Drapers. Go *up first big wash* below Draper's and follow it to base of peak, then

go up the way which looks best. A very rough country around this station, and animals can only go a short distance. Plenty of water after rain—for months—in big wash east of station.

Station mark: A bronze triangulation tablet cemented in solid rock under center of a cairn 8 feet high.

[Latitude 33° 07′ 27.94″. Longitude 114° 44′ 29.86″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Quartz	62 27 09.90	242 24 30.43	3.9314387
Fort Gass	171 47 04.97	351 45 55.50	4.3607200
Chocolate	224 06 37.64	44 12 29.87	4.3786581
Clip	279 59 10.13	100 04 17.14	4.1701718

NO. 17, SAN DIEGO COUNTY.

(Not occupied.)

On edge of second bench of low mesa about 1 mile from Colorado River, and is about 1½ miles above upper end of slough which forms Apache Island, on the Arizona side of the river. Can best be reached by getting directions from No. 18 or Fort Gass. Station is close to river bottom and is 2½ miles north 25° west from No. 18, and 3½ miles north 78° east from Fort Gass. The wagon road from Ehrenberg to Picacho passes close on the east side of station.

Station mark: A bronze triangulation tablet cemented in rock and placed in ground level with surface. A pit opposite each leg of tripod and a mound around each leg.

[Latitude 33° 22′ 01.64″. Longitude 114° 44′ 20.16″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fort Gass	30 00 36.78	219 59 21.76	3.73956
Chocolate	300 43 48.21	120 49 36.24	4.28041
Mulewash			4.26595
Hodges			4.12910
No. 16			4.10664
No. 18			3.55739

NO. 18, SAN DIEGO COUNTY.

On a little rocky peak about 400 yards from the Colorado River, at the lower end of a small slough. The wagon road from Ehrenberg to Picacho passes on the west side of the peak about 300 yards, the peak being between the road and the river. The bluff is very close to

water's edge at this point of the river. Station is about 35 miles by the river below Ehrenberg and 30 miles up the river from Picacho.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 33° 20′ 19.96″. Longitude 114° 43′ 10.82″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fort Gass	78 36 56.30	258 35 03.20	3.73479
Chocolate	294 22 48.62	114 27 58.44	4.20491
Mulewash			4.27211
Hodges			4.22373
No. 17			3.55739
No. 16			4.13086
No. 19			3.98436

NO. 19, SAN DIEGO COUNTY.

(Not occupied.)

On the edge of mesa where it bluffs to the Colorado River bottom, and is about one-half mile from the river at the nearest point. At the lower end of Apache Island the river makes a horseshoe bend to the east-northeast; about the middle of this bend the slough forming this island rejoins the river. No. 19 is about the middle of the heel of this horseshoe.

Station mark: A bronze triangulation tablet cemented in rock and placed in ground level with surface.

[Latitude 33° 15′ 13.52″. Longitude 114° 41′ 54.39″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fort Gass	138 54 31.93	318 51 57.01	4.04557
Chocolate	257 23 58.78	77 28 26.34	4.11172
Lava			4.17314
No. 18			3.98436
Quartz			4.33563

NO. 20, SAN DIEGO COUNTY.

(Not occupied.)

On summit of a sharp rocky peak about a mile from the Colorado River and about the same distance from Draper's ranch at Lighthouse Rock, and bears north 39° west from Mr. Draper's, about 18 miles up the river from Picacho.

Station mark: A bronze triangulation tablet cemented in rock under center of a cairn 9 feet high.

[Latitude 33° 10′ 00.66″. Longitude 114° 41′ 41.91″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lava	42 47 18.43	222 45 46.60	3.80682
Fort Gass	157 03 32.98	337 00 51.39	4.29127
Chocolate			4.24321
Clip			4.09842

NO. 21, SAN DIEGO COUNTY.

(Not occupied.)

On a rocky hill, the highest point of a group of hills lying close to the Colorado River and about 10 miles by river or wagon road, up the river from Picacho. The road passes on the south side of the station and the river on the north side. Station is about one-half mile from the river and one-fourth mile from the road.

Station mark: A bronze triangulation tablet cemented in rock placed under center of a cairn 8 feet high.

[Latitude 33° 04′ 31.87″. Longitude 114° 41′ 35.82″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
American	12 54 33.43	192 52 37.38	4.39485
Clip	254 10 07.37	74 13 39.17	4.01938
Lava			3.84857

NO. 22, SAN DIEGO COUNTY.

(Not occupied.)

On summit of first peak south of Picacho and is in plain view and is about three-fourths mile distant from town. There is a small rock cairn on highest point which is a mining location corner. Signal is close by and is a little lower but not enough to prevent a good view in every direction.

Station mark: A bronze triangulation tablet cemented in rock and placed in ground under center of a cairn 8 feet high.

[Latitude 33° 00′ 59.63″. Longitude 114° 36′ 21.30″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
American	37 52 01.06	217 47 14.08	4.34942
Ridge	343 21 50.04	163 23 13.44	4.14358
Quartz			4.33800
Lava			4.24125
Clip			3.98123

NO. 23, SAN DIEGO COUNTY.

(Not occupied.)

On a very prominent sharp peak, about 4 miles southeast of Picacho, and visible from that place. A wood road leads to foot of peak from Picacho. Peak is hard to climb, but can be occupied.

Station mark: A bronze triangulation tablet cemented in rock and placed under center of a cairn 8 feet high.

[Latitude 32° 59′ 48.33″. Longitude 114° 33′ 07.86″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Ridge	5 20 48.71	185 20 26.89	4.04876
American	50 31 31.41	230 24 59.36	4.38550
Clip			4.07897
Lava			4.35529
Quartz			4.43544

PICACHO, SAN DIEGO COUNTY.

(Not occupied.)

A well-known sharp peak, about 6 miles southwest of Picacho town.

Station mark: Center of highest monument.

[Latitude 32° 58′ 18.94″. Longitude 114° 39′ 50.18″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
American	33 07 52.61	213 04 59.31	4.18105
Ridge	311 40 45.02	131 44 01.94	4.10051
Clip			4.20680
Quartz			4.29443

PILOT, SAN DIEGO COUNTY.

A station of the United States and Mexican Boundary Commission, on the highest point of a butte of the same name, about 10 miles west of Yuma on the California side of the Colorado River. Reached from Yuma by crossing the river on the ferry and taking road through the Indian reservation to old stage station, where you strike the Southern Pacific Railroad again. Follow road along south side of railroad for 2 miles, then turn off across country to foot of butte.

Station mark: No mark was put in by the Boundary Commission, and the signal had blown down. A rock monument 6 feet high was built over the center, as nearly as it could be determined.

Reference mark: A bronze triangulation tablet cemented in solid rock, true azimuth from rock monument, 242° 07′, distance 11.3 feet.

[Latitude 32° 43′ 55.42″; 32° 43′ 58.83″.[a] Longitude 114° 44′ 47.99″; 114° 44′ 49.68″.[a]]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
American	177 44 15.19	357 44 03.76	4.1430949
Ridge	223 15 29.56	43 21 27.24	4.3984893
Sugarloaf	254 53 04.41	75 01 33.12	4.4037670
Yuma azimuth	280 44 17.76	100 48 27.64	4.0882718

[a] Position on Yuma data of the United States and Mexican Boundary Survey Commission.

QUARTZ, SAN DIEGO COUNTY.

On the highest point of a range of mountains lying between the Southern Pacific Railway and the Colorado River, about 8 miles from the river at Draper's ranch and probably 15 miles from the railway.

Station mark: A bronze triangulation tablet cemented in rock placed under center of a cairn 8 feet high.

[Latitude 33° 05′ 19.64″. Longitude 114° 49′ 21.82″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fort Gass	189 06 07.87	9 07 38.33	4.4314275
Lava	242 24 30.43	62 27 09.90	3.9314387
Clip	266 22 50.93	86 30 37.22	4.3461066
American	345 38 23.65	165 40 41.19	4.4231629

RIDGE, SAN DIEGO COUNTY.

On summit of a high black ridge lying about 14 miles north, 10° west, of Yuma, Ariz. This ridge is long and wide, being several miles across it either way. Station is on one of the highest points where

ridge breaks off to the north, giving a good view of the lowlands of the Colorado River in the big bend east of Picacho. The best way to go there is from Potholes, 12 miles from Yuma by road.

Station mark: A bronze triangulation tablet cemented in rock in place under a cairn 9 feet high.

[Latitude 32° 53′ 46.72″. Longitude 114° 33′ 47.98″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Yuma azimuth	14 05 58.85	194 04 11.71	4.3251262
Pilot	43 21 27.24	223 15 29.56	4.3984893
American	76 19 48.46	256 13 38.72	4.2607025
Clip	174 47 27.17	354 46 43.66	4.3582402
Sugar Loaf	327 56 29.74	147 59 01.62	4.1376339

Four new stations for the control of the Coalinga Special Map in Fresno County were occupied by Mr. A. H. Sylvester in October, 1902. This work was based upon the positions of Hepsedam and Castle Mount on the standard datum of the United States Coast and Geodetic Survey.

HEPSEDAM, SAN BENITO COUNTY.

A station of the United States Coast and Geodetic Survey on a prominent peak of the Mount Diablo range, in the southern part of the county. It can be reached from Coalinga by road via King City, Marthan Canon, Priest Valley, and down Lewis Creek to Captain Holletts.

Station mark: A hole drilled in outcropping rock and filled with lead.

[Latitude 36° 18′ 53.60″. Longitude 120° 49′ 26.36″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Oak Flat	299 44 51.81	119 55 16.47	4.4829865
Center Peak	304 30 56.00	124 38 04.00	4.3414790
Castle Mount	313 34 08.71	133 51 16.62	4.7804191

CASTLE MOUNT, MONTEREY-FRESNO COUNTIES.

A station of the United States Coast and Geodetic Survey on a high hogback, locally known as Black Mountain. It can be reached from Coalinga by rough road and trail via Parkfield, Turkey Flat, and Taylor's ranch, where accommodations can be had.

Station mark: A copper bolt in center of top of theodolite pier.

[Latitude 35° 56′ 21.34″. Longitude 120° 20′ 22.91″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hepsedam	133 51 16.62	313 34 08.71	4.7804191
Center Peak			4.5887373
Oak Flat	147 07 51.82	327 01 07.45	4.5001282
Alcalde	164 49 51.29	344 47 38.90	4.3325900
Oil City	178 11 52.42	358 11 24.69	4.5722254
Black Tank	181 45 18.82	1 45 35.92	4.3727723
Kinney	191 42 50.45	11 45 05.29	4.4500045

OAK FLAT, FRESNO COUNTY.

On the highest point of a range of mountains east of Pleasant Valley and between the Marthan Creek drainage on the south and Los Gatos Creek drainage on the north. It is best reached from Coalinga via Oak Flat. Kinney, the hotel and stable man at Coalinga can give directions. There is an unoccupied house and a spring at Oak Flat. From there a horse can be ridden to the station, about 2 miles distant, though there is no trail. It is better to keep up the Oak Flat canyon for half a mile above the flat and take up a ridge between two forks of the canyon.

Station mark: A bowlder was planted firmly in the earth and marked with a drill hole and triangle and the letters U. S. G. S.

[Latitude 36° 10′ 42.80″. Longitude 120° 31′ 49.89″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hepsedam	119 55 16.47	299 44 51.81	4.4829865
Oil City	235 57 38.45	56 03 56.64	4.2849789
Kinney	267 18 42.12	87 27 42.88	4.3600623
Black Tank	279 22 04.45	99 29 06.89	4.2585579
Alcalde	296 36 42.27	116 41 14.75	4.1112119
Castle Mount	327 01 07.45	147 07 51.82	4.5001282

OIL CITY, FRESNO COUNTY.

This station is on a round topped hill about 0.5 mile northeast of Oil City. When going to it from Coalinga take road to Oil City, but turn to right up another when in sight but before passing a large black iron tank. Follow this road and it will lead to within 200 yards of signal. A team can be driven to signal, though it is rather steep.

Station mark: A bowlder set solidly into the earth and marked with a drill hole and triangle and the letters U S G S.

U S
△
G S

[Latitude 36° 16′ 32.37″. Longitude 120° 21′ 09.97″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Alcalde	15 02 48.84	195 00 51.45	4.2344037
Oakflat	56 03 56.64	235 57 38.45	4.2849789
Kinney	324 39 52.94	144 42 31.98	4.0764584
Castle Mount	358 11 24.69	178 11 52.42	4.5722254

KINNEY, FRESNO COUNTY.

On the highest part of the south end of the low ridge bounding Pleasant Valley on the east. It is about 5 miles northeast of Coalinga, and the signal can be seen from town. A team can be driven directly to the station.

Station mark: A large stone was set solidly into the earth and marked with a drill hole and triangle and the letters U S G S.

[Latitude 36° 11′ 16.68″. Longitude 120° 16′ 33.91″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Castle Mount	11 45 05.29	191 42 50.45	4.4500045
Black Tank	51 15 35.29	231 14 04.09	3.8070674
Alcalde	58 58 05.85	238 53 37.93	4.1222781
Oakflat	87 27 42.88	267 18 42.12	4.3600623
Oil City	144 42 31.98	324 39 52.94	4.0764584

ALCALDE, FRESNO COUNTY.

On the highest point of the first ridge west of Pleasant Valley, about 3 miles from town of Coalinga. A team can be driven within 100 yards of top.

Station mark: The regulation 4-brace center mast sawed timber signal, 10 feet high. The mast is set into the ground 3 feet.

[Latitude 36° 07′ 34.80″. Longitude 120° 24′ 07.99″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Oakflat	116 41 14.75	296 36 42.27	4.1112119
Oil City	195 00 51.45	15 02 48.84	4.2344037
Kinney	238 53 37.93	58 58 05.85	4.1222781
Black Tank	246 00 04.45	66 02 34.59	3.8419342
Castle Mount	344 47 38.90	164 49 51.29	4.3325900

BLACK TANK, FRESNO COUNTY.

(Not occupied.)

The third tank, counting from the east, standing by the railroad, east of Coalinga.

Station mark: Center of tank.

[Latitude 36° 09′ 06.43″. Longitude 120° 19′ 54.02.″]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Castle Mount	1 45 35.92	181 45 18.82	4.3727723
Alcalde	66 02 34.59	246 00 04.45	3.8419342
Oakflat	99 29 06.89	279 22 04.45	4.2585579
Kinney	231 14 04.09	51 15 35.29	3.8070674

Additional control in the vicinity of Redding was obtained by Mr. Geo. T. Hawkins, topographer, who located three new secondary stations from Bass and Redding court-house, previously located by the 3-point method from mounts Lassen, Linn, and Shasta.

SOUTH FORK, SHASTA COUNTY.

On South Fork Mountain, three-fourths mile nearly south of the Mountain copper mine, on southern of double-topped mountains. Scattering trees on summit.

Station mark: The tall pine signal tree 36 inches in diameter, marked U S at base.

[Latitude 40° 39′ 10.0″. Longitude 122° 31′ 31.2″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Shirt	164 46 17.00	344 45 11.00	3.95903
Sugar loaf	196 53 21.00	16 53 53.00	3.59760
Bass	236 45 09.00	56 51 19.00	4.20237
Redding	306 12 40.00	126 17 41.00	4.12993

SUGAR LOAF, SHASTA COUNTY.

About 2 miles northeast of the Mountain Copper Mine on a sharp peak locally known as Sugar Loaf. Most of timber cleared from top.

Station mark: The pine signal tree trimmed up with tuft left at top, 18 inches in diameter and marked "U. S." at base.

[Latitude 40° 41′ 12.8″. Longitude 122° 30′ 42.2″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bass	247 53 42	67 59 20	4.11873
Redding	320 23 24	140 27 53	4.18361
South Fork	16 53 53	196 53 21	3.59760
Shirt	144 40 09	324 38 31	3.78661

SHIRT, SHASTA COUNTY.

On the western of two bald knobs, about 6 miles north and 1 mile west of the Mountain Copper Mine and 1 mile northeast of the Gladstone Mine.

Station mark: A cairn 6 feet high and 4 feet diameter at base, erected over a + and "U. S." cut in solid rock.

[Latitude 40° 43′ 54.5″. Longitude 122° 33′ 12.9″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bass	270 07 32	90 14 49	4.19631
Sugarloaf	324 38 31	144 40 09	3.78661
South	344 45 11	164 46 17	3.95903

OREGON.

TRIANGULATION STATIONS.

Triangulation in northeastern Oregon was extended from stations in the expansion of the Baker City base so as to control 3 thirty-minute quadrangles. Fourteen stations were occupied by Mr. C. F. Urquhart, topographer.

IMNAHA, BAKER COUNTY.

On the highest summit in southeast corner of Eagle Mountains, about 2 miles east from corner of Baker, Union, and Wallowa counties, probably in Baker County, and is sometimes known as Red Mount. The Imnaha River (Kettle Creek) heads at its base and flows eastnortheast. Little Eagle Creek flows southwest and Pine Creek

flows southeast. The Joseph and Cornucopia trail passing about 3 miles east from station at a point 7 or 8 miles from latter. The best route to mountain is by trail up Kettle Creek from the north side. Camp at head of Kettle Creek; station will be in sight. From the south this point can be reached from the Union and Cornucopia road by leaving road at a point 4 miles east from the Eagle Creek bridge, thence north by road to Reid's mine, thence by trail to head of Kettle Creek.

Station mark: A bronze triangulation tablet set in loose rock, with a cairn 6 feet at base, 7½ feet high, built over it.

[Latitude 45° 03′ 54.09″. Longitude 117° 14′ 50.49″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lookout	2 53 26.56	182 52 04.81	4.7049400
Little Lookout	12 48 44.60	192 43 44.00	4.6263384
Sparta	19 04 42.26	199 01 01.00	4.3225192
Lone Pine	48 36 32.34	228 15 38.01	4.7167727
Magpie	73 10 53.44	252 47 05.72	4.6650302
China Cap	116 08 21.25	295 57 07.51	4.3643332
Fanny	125 35 52.92	305 15 16.81	4.6691541
Hurricane	163 49 50.28	343 45 38.80	4.4430293
Aneroid	188 16 24.02	8 17 29.55	4.1469960

LITTLE LOOKOUT, BAKER COUNTY.

Station is on highest point of Little Lookout Mountain and near the source of Lawrence Creek on the north and Durkee Creek on the south. There is a road from Baker City to sawmill on Lawrence Creek, thence up creek to Mr. S. W. Dean's residence, thence southwest up ridge, about 2 miles to signal. Can ride on ridge anywhere.

Station mark: A bronze triangulation tablet set in solid rock, with a cairn 6 feet at base and 7 feet high built over it.

[Latitude 44° 41′ 37.69″. Longitude 117° 21′ 56.50″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lone Pine	102 49 06.09	282 33 15.62	4.4838587
Magpie	128 32 10.63	308 13 27.82	4.6497947
China Cap	167 25 46.08	347 19 35.34	4.7216992
Sparta	186 36 52.07	6 38 11.69	4.3331114
Imnaha	192 43 44.00	12 48 44.60	4.6263384
Lookout	323 53 01.94	143 56 39.86	4.0644696

LOOKOUT, BAKER COUNTY.

On the summit of Big Lookout Mountain a well-known high point near the head of Manning Creek. There is a wagon road from Durkee or Express to the head of Manning Creek.

Station mark: A cairn 8 or 9 feet at base and 10 feet high.

[Latitude 44° 36′ 33.99″. Longitude 117° 16′ 46.42″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lone Pine	113 52 32.67	293 33 04.86	4.6015032
Magpie	131 44 39.42	311 22 19.04	4.7475534
Little Lookout	143 56 39.86	323 53 01.94	4.0644696
Sparta	171 59 54.71	351 57 36.52	4.4923373
Imnaha	182 52 04.81	2 53 26.56	4.7049400

SPARTA, BAKER COUNTY.

Station is on summit of a bald hill locally known as "Little Baldy," about 1 mile north-northwest from Sparta, a small mining town and post-office 32 miles east-northeast from Baker City. There is also a pole about 30 feet high used for Fourth of July purposes near the summit of hill. This pole was not used for signal, but a cairn about 6 feet high on highest point.

Station mark: A bronze triangulation tablet set in solid rock, over which was built a cairn 6 feet high.

[Latitude 44° 53′ 10.62″. Longitude 117° 20′ 03.48″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lookout	351 57 36.52	171 59 54.71	4.4923373
Little Lookout	6 38 11.69	186 36 52.07	4.3331114
Lone Pine	65 34 51.51	245 17 39.76	4.5484964
Magpie	99 46 12.88	279 26 08.38	4.5792338
Imnaha	199 01 01.00	19 04 42.26	4.3225192

CHINA CAP, UNION COUNTY.

Station is on the summit of a high, red mountain near the source of Catherine Creek and on the range of mountains between Catherine Creek and Minum River. There is a sharp red peak about 1 mile south from station with a small monument on it. This point is the first red peak, all of the high mountains east-southeast being white granite. To reach station from the south, a steep trail passes to the *east and near the* base of the peak. At this point the signal can be

plainly seen about 1 mile north. There is a trail (good) from Medicine Springs to the head of Big Creek, thence northwest down steep hill to Catherine Creek, thence northwest over end of ridge to sheep camp, thence up bare ridge to low place in mountains near foot of small peak, from which station can be seen. Head of Big Creek can also be reached via road to Basin mine, which leaves Union and Cornucopia road 4 miles west from Sanger.

Station mark: A bronze triangulation tablet set in solid rock, with a cairn 7 feet at base and 9 feet high built over it.

[Latitude 45° 09′ 23.20″. Longitude 117° 30′ 41.46″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Imnaha	295 57 07.51	116 08 21.25	4.3643332
Little Lookout	347 19 35.34	167 25 46.08	4.7216992
Magpie	44 42 49.38	224 30 13.55	4.5221799
Craig	95 33 54.01	275 16 28.66	4.5096415
Fanny	134 27 58.41	314 18 36.49	4.3830935
Hurricane	218 14 39.52	38 21 42.97	4.3220569
Aneroid	260 37 11.97	80 49 32.02	4.3633677

CRAIG, UNION COUNTY.

On the highest point of Craig Mountain, about 4 miles southwest from Union. The shortest way to reach it is by trail. Cross the railroad and enter pasture at Union station, thence up rather steep hill to summit. It can also be reached by road by leaving Union and Baker City road 5 miles from the former, cross small valley in lane, thence up canyon to summit of ridge. Station will be in view.

Station mark: A bronze triangulation tablet set in loose rock between two large rocks. A cairn 6 feet at base, 7 feet high, built over tablet.

[Latitude 45° 11′ 02.13″. Longitude 117° 55′ 15.44″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Emily	184 10 12.18	4 11 20.18	4.4561684
Fanny	227 00 07.82	47 08 12.49	4.3081147
China Cap	275 16 28.66	95 33 54.01	4.5096415
Magpie	341 35 18.42	161 40 05.82	4.4499851

EMILY, UNION COUNTY.

On highest point of ridge between Indian Creek and the Grande Ronde River. The mountain is called Mount Emily by some people, but others call the highest ridge on the west side of the valley by that name. The best way to reach the station is from Mr. Childers's residence, which is near the summit of ridge. Road comes up the ridge from lower cove. From Mr. Childers travel Indian Creek road 1 mile, then take all left roads until cabin is reached, thence to the right and up ridge to spring, thence up to station, 4 miles from Mr. Childers. There is a bunch of trees northwest from signal higher.

Station mark: A bronze triangulation tablet set in solid rock.

[Latitude 45° 26′ 25.67″. Longitude 117° 53′ 39.79″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Huckleberry	273 02 46.60	93 19 46.43	4.4936632
Hurricane	289 09 20.46	109 32 45.89	4.6584362
Fanny	318 53 35.55	139 00 33.22	4.2888142
Craig	4 11 20.18	184 10 12.18	4.4561684

FANNY, UNION COUNTY.

On highest point on rocky mountain about one-fourth mile east-southeast from Mount Fanny, a well-known mountain about 5 miles east from Cove, Oreg. There is a trail from Mr. Murphy's residence, 2 miles east from Cove, to station.

Station mark: A bronze triangulation tablet set in solid rock, with a cairn 6 feet base and 6 feet high (tree in center) built over it.

[Latitude 45° 18′ 30.65″. Longitude 117° 43′ 52.93″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Craig	47 08 12.49	227 00 07.82	4.3081147
Emily	139 00 33.22	318 53 35.55	4.2888142
Huckleberry	234 47 21.90	54 57 22.96	4.3516867
Hurricane	270 40 17.63	90 56 44.28	4.4805756
Imnaha	305 15 16.81	125 35 52.92	4.6691541
China Cap	314 18 36.49	134 27 58.41	4.3830935
Magpie	8 29 39.82	188 26 23.87	4.6132078

ANEROID, WALLOWA COUNTY.

About 2 miles southwest from Aneroid Lake. Water flows into the Wallowa, East Wallowa, and Imnaha from the point. The Joseph and Cornucopia trail passes about 1 mile east of station at a point 15 or 16 miles from Joseph. To reach station by trail, travel on the Joseph and Cornucopia trail until the summit or divide between East Wallowa and Imnaha is reached, thence west up ridge 1 mile to station. Monument can be seen from trail on summit.

Station mark: A bronze triangulation tablet set in loose rock with a cairn 6 feet at base, 7 feet high, built over it.

[Latitude 45° 11′ 23.77″. Longitude 117° 13′ 18.02″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Imnaha	8 17 29.55	188 16 24.02	4.1469960
China Gap	80 49 32.02	260 37 11.97	4.3633677
Hurricane	142 38 52.91	322 33 35.48	4.2054926

BRUMBACK, WALLOWA COUNTY.

Station is on the highest part of a prominent bald butte about one-half mile east from Mr. E. Brumback's residence, and is in the southeast quarter of section 24, T. 1 N., R. 46 E. The butte is the most northern of two buttes about 3 miles from each other. By wagon road it is 18 miles east-northeast from Enterprise, and about the same distance from Joseph.

Station mark: A bronze triangulation tablet set in solid rock over which is erected a cairn 6½ feet at base and 9½ feet high.

[Latitude 45° 32′ 46.78″. Longitude 116° 59′ 38.72″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hurricane	45 49 59.04	225 34 57.01	4.5850060
Huckleberry	71 13 18.68	250 51 48.31	4.6185922

HURRICANE, WALLOWA COUNTY.

The highest and most southeastern of two very sharp peaks, sometimes called "The Sisters," on the highest part of ridge between Hurricane Creek and the most eastern fork of the South Fork of the Wallowa River. To reach station, take trail up Hurricane Creek about 3 miles, when the second creek coming into Hurricane from the west is reached, peak can be seen up this stream. From this point to station (about 3 miles) it is too steep and rough to travel with horses.

Station mark: A bronze triangulation tablet set in soft rock on summit of peak.

[Latitude 45° 18′ 16.83″. Longitude 117° 20′ 45.00″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Aneroid	322 33 35.48	142 38 52.91	4.2054926
Imnaha	343 45 38.80	163 49 50.28	4.4430293
China Gap	38 21 42.97	218 14 39.52	4.3220569
Fanny	90 56 44.28	270 40 17.63	4.4805756
Emily	109 32 45.89	289 09 20.46	4.6584362
Huckleberry	138 32 27.20	318 26 00.60	4.2513815
Brumback	225 34 57.01	45 49 59.04	4.5850060

HUCKLEBERRY, WALLOWA COUNTY.

A high bald ridge between the East Fork of Bear Creek and Little Bear Creek, about 1 mile north-northwest from head of Little Bear Creek, and 7 miles by trail south-southwest from Lostine post-office. Follow wagon road about 1 mile to Mr. McCubbin's ranch; thence 1 mile by road to gulch; thence up steep trail to summit of timbered ridge. From summit of this ridge the station can be seen. Follow trail about south, cross Little Bear Creek, thence up steep trail to summit of bald ridge.

Station mark: A bronze triangulation tablet set in loose rock 1 foot below surface, over which is a rock marked U S / G S

[Latitude 45° 25′ 29.53″. Longitude 117° 29′ 48.30″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Brumback	250 51 48.31	71 13 18.68	4.6185922
Hurricane	318 26 00.60	138 32 27.20	4.2513815
Fanny	54 57 22.96	234 47 21.90	4.3516867
Emily	93 19 46.43	273 02 46.60	4.4936632

WASHINGTON—IDAHO.

TRIANGULATION STATIONS.

Triangulation for control of 3 thirty-minute quadrangles in southeastern Washington was extended southward from stations in the expansion of the Spokane base. Besides reoccupying 2 old stations 17 new stations were built and occupied and 4 points located by intersections by Mr. George T. Hawkins, topographer in 1902.

Washington.

ANATONE, ASOTIN COUNTY.

On a bald knob 6.5 miles southwest from Anatone and 250 feet south of Anatone and Grande Ronde Valley road, 0.25 mile south of big wooded butte.

Station mark: + cut in rock and pile of stone over it.

[Latitude 46° 06′ 29.23″. Longitude 117° 15′ 21.22″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
White	162 40 01.34	342 35 48.08	4.40120
Windmill	233 30 39.56	53 39 06.74	4.27300
Billy Creek	273 38 04.46	93 54 05.32	4.46123

WHITE, ASOTIN COUNTY.

On a high bald knob in a field 400 feet north of Lewiston and Peola road, 20 miles from Lewiston and 8 miles from Peola.

Station mark: U. S. + cut in solid rock.

[Latitude 46° 19′ 27.80″. Longitude 117° 21′ 12.01″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Valentine	183 39 39.03	3 40 22.94	4.3062636
Snake	228 03 20.72	48 13 21.11	4.3762899
Windmill	299 39 38.88	119 52 20.44	4.4149990
Anatone	342 35 48.08	162 40 01.34	4.4012000

WINDMILL, ASOTIN COUNTY.

Center of windmill at east end of Mr. Bolock's barn, 12 miles south of Asotin and 0.5 mile east of Asotin and Anatone road.

Station mark: Center of windmill.

[Latitude 46° 12′ 29.72″. Longitude 117° 03′ 38.03″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Anatone	53 39 06.74	233 30 39.56	4.2730000
White	119 52 20.44	299 39 38.88	4.4149990
Valentine	147 25 22.04	327 13 23.19	4.5947866
Snake	170 32 12.41	350 29 29.75	4.4650820
Billy Creek	313 24 47.81	133 32 29.72	4.2774400

CHENEY, SPOKANE COUNTY.

About 4 miles northwest of Cheney and same distance southeast of Medical Lake on highest bald knob in that vicinity.

Station mark: Iron bench-mark post set 36 inches in the ground.

[Latitude 47° 32′ 54.26″. Longitude 117° 36′ 40.32″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tompkinson	210 05 42.97	30 12 31.93	4.3617486
Little Baldy	229 53 39.91	50 06 02.07	4.4374457
Paradise	280 40 58.56	100 50 10.43	4.2021346
Waverly	303 55 42.06	124 16 49.80	4.6390466
Plaza	332 45 41.14	152 53 00.52	4.4372139

PARADISE, SPOKANE COUNTY.

About 1 mile from Paradise post-office, on a prominent wooded hill. Part of timber cut down.

Station mark: A pine tree 10 inches in diameter on line of east and west fence.

[Latitude 47° 31′ 17.98″. Longitude 117° 24′ 13.21″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Plaza	8 28 14.74	188 26 23.12	4.3345800
Cheney	100 50 10.43	280 40 58.56	4.2021347
Tompkinson	169 56 24.74	349 54 00.95	4.3658765
Little Baldy	194 33 55.19	14 37 04.62	4.3275653
Waverly	316 20 36.95	136 32 33.51	4.4712470

PLAZA, SPOKANE COUNTY.

On a cleared hill 2.5 miles west and 1 mile north of Plaza, and 0.25 mile southwest from Mr. Lybecker's residence 150 feet east of road in field.

Station mark: An iron bench-mark post set 36 inches in the ground.

[Latitude 47° 19′ 45.97″. Longitude 117° 26′ 44.79″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sunset	2 36 22.53	182 35 38.82	4.4414637
Cheney	152 53 00.52	332 45 41.14	4.4372139
Paradise	188 26 23.12	8 28 14.74	4.3345800
Waverly	270 04 21.24	90 18 08.14	4.3731774
Steptoe	341 15 49.85	161 22 19.28	4.5428294

WAVERLY, SPOKANE COUNTY.

On a bald butte 4.5 miles east of Waverly.

Station mark: A stone block 20 by 8 by 8 inches set 24 inches in ground; top marked "+ U. S."

[Latitude 47° 19′ 43.47″. Longitude 117° 08′ 00.15″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Steptoe	20 49 03.51	200 41 48.02	4.5474520
Plaza	90 18 08.14	270 04 21.24	4.3731774
Cheney	124 16 49.80	303 55 42.06	4.6390466
Paradise	136 32 33.51	316 20 36.95	4.4712470
Ladow	352 16 07.44	172 19 03.97	4.5776636

VALENTINE, GARFIELD COUNTY.

On land owned by Mr. Ed. Davis 1.5 miles northeast of Valentine post-office, about 0.5 mile northwest of his residence, in field.

Station mark: A sandstone block 30 by 25 by 15 inches set 30 inches in the ground; top marked "+ U. S."

[Latitude 46° 30′ 22.03″. Longitude 117° 20′ 11.39″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
White	3 40 22.94	183 39 39.03	4.3062636
Wawawai	188 57 02.26	8 58 41.36	4.2703883
Colton	243 06 16.93	63 12 36.63	4.0967792
Snake	284 43 02.46	104 52 19.79	4.2292579
Windmill	327 13 23.19	147 25 22.04	4.5947866

BALD, WHITMAN COUNTY.

On a high bald butte, 2.5 miles east of Johnsons, near southeast corner sec. 1, T. 13, R. 45.

Station mark: An iron bench-mark post set 38 inches in the ground.

[Latitude 46° 37′ 59.29″. Longitude 117° 05′ 22.23″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Snake	7 56 35.86	187 55 08.27	4.2701383
Colton	42 37 09.70	222 32 43.82	4.0611784
Wawawai	105 04 52.91	284 55 45.52	4.2193539
Kamiak	166 39 07.99	346 35 40.55	4.4171589
Ladow	182 30 52.52	2 31 52.93	4.0009249

COLFAX, WHITMAN COUNTY.

About 5 miles nearly west from Colfax, on mound in field 250 feet south of road.

Station mark: An iron bench-mark post set 40 inches in the ground.

[Latitude 46° 51′ 31.28″. Longitude 117° 27′ 14.82″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sunset	178 33 24.24	358 33 02.65	4.3933151
Steptoe	211 33 29.96	31 40 19.86	4.3547119
Kamiak	268 58 40.51	89 11 10.47	4.3379294
Wawawai	330 11 26.06	150 18 13.94	4.3791007

COLTON, WHITMAN COUNTY.

On east end of mound in a field 2.5 miles nearly west from Colton, in sec. 5, T. 12, R. 45.

Station mark: An iron bench-mark post set 42 inches in the ground.

[Latitude 46° 33′ 24.77″. Longitude 117° 11′ 28.20″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Valentine	63 12 36.63	243 06 16.93	4.0967792
Wawawai	147 13 56.63	327 09 15.55	4.1815599
Bald	222 32 43.82	42 37 09.70	4.0611784
Snake	332 17 56.68	152 20 54.67	4.0515403

KAMIAK, WHITMAN COUNTY.

On highest point of Kamiak butte, 7 miles southwest from Palouse and about 8 miles south and east from Colfax. Most of timber cut down.

Station mark: The pine signal tree 18 inches in diameter trimmed and marked U. S.

[Latitude 46° 51′ 42.57″. Longitude 117° 10′ 07.04″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wawawai	25 12 52.35	205 07 11.43	4.3682540
Colfax	89 11 10.47	268 58 40.51	4.3379295
Steptoe	152 29 48.23	332 24 07.12	4.3292802
Ladow	208 16 47.71	28 21 16.27	4.2147588
Bald	346 35 40.55	166 39 07.99	4.4171589

LADOW, WHITMAN COUNTY.

On a bald butte 6 miles north of Palouse and 3.5 miles nearly east of Garfield, near corner secs. 1, 6, 7, 12, T. —, Rs. 45, 46.

Station mark: An iron bench-mark post set 40 inches in the ground.

[Latitude 46° 59′ 30.01″. Longitude 117° 03′ 59.40″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bald	2 31 52.93	182 30 52.52	4.6009249
Kamiak	28 21 16.27	208 16 47.71	4.2147588
Steptoe	104 22 25.20	284 12 14.80	4.2598009
Waverly	172 19 03.97	352 16 07.44	4.5776636

PULLMAN, WHITMAN COUNTY.

(Not occupied.)

The water tower in grounds of Agricultural College at Pullman.

Station mark: Center of water tower.

[Latitude 46° 43′ 49.08″. Longitude 117° 09′ 49.34″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kamiak	178 31 53.44	358 31 40.55	4.16520
Bald	332 14 33.66	152 17 47.99	4.08635

SNAKE, WHITMAN COUNTY.

On a high point 6 miles south and 1 mile west of Uniontown, on edge of Snake River Canyon.

Station mark: An iron bench-mark post set 40 inches in the ground.

[Latitude 46° 28′ 01.83″. Longitude 117° 07′ 22.88″.]

To station	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
White	48 13 21.11	228 03 20.72	4.3762899
Valentine	104 52 19.79	284 43 02.46	4.2292579
Colton	152 20 54.67	332 17 56.68	4.0515403
Bald	187 55 08.28	7 56 35.86	4.2701383
Billy Creek	336 00 52.15	156 11 17.75	4.6602700
Windmill	350 29 29.75	170 32 12.41	4.4650820

STEPTOE, WHITMAN COUNTY.

On cupola of hotel on top of Steptoe butte, about 7 miles nearly south from Oakesdale.

Station mark: Center of cupola.

Reference mark: + cut in solid rock 55 feet due north of center of cupola.

[Latitude 47° 01′ 55.38″. Longitude 117° 17′ 53.86″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Colfax	31 40 19.86	211 33 29.96	4.3547119
Sunset	113 41 54.62	293 34 42.36	4.1336609
Plaza	161 22 19.28	341 15 49.85	4.5428294
Waverly	200 41 48.02	20 49 03.51	4.5474520
Ladow	284 12 14.80	104 22 25.20	4.2598009
Kamiak	332 24 07.12	152 29 48.23	4.3292801

SUNSET, WHITMAN COUNTY.

On a mound in a field 2.5 miles south and 0.5 mile east of Sunset, 0.25 mile east of Mr. Macklin's residence.

Station mark: An iron bench-mark post set 36 inches in the ground.

[Latitude 47° 04′ 52.02″. Longitude 117° 27′ 44.36″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Plaza	182 35 38.82	2 36 22.53	4.4414637
Steptoe	293 34 42.36	113 41 54.62	4.1336609
Colfax	358 33 02.65	178 33 24.24	4.3933151

WAWAWAI, WHITMAN COUNTY.

On mound in a field 8 miles southwest of Pullman in northeast quarter sec. 29, T. 14, R. 44.

Station mark: An iron bench-mark post set 40 inches in the ground.

[Latitude 46° 40′ 18.24″. Longitude 117° 17′ 54.97″.]

To station—	Azimuth	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Valentine	8 58 41.36	188 57 02.26	4.2703883
Colfax	150 18 13.94	330 11 26.06	4.3791007
Kamiak	205 07 11.43	25 12 52.35	4.3682540
Bald	284 55 45.52	105 04 52.91	4.2193539
Cotton	327 09 15.55	147 13 56.63	4.1815599

Idaho.

MOSCOW, LATAH COUNTY.

(Not occupied.)

Station mark: Center of water tower at Moscow.

[Latitude 46° 44′ 05.88″. Longitude 116° 59′ 57.63″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bald	31 24 00.17	211 20 03.99	4.12231
Kamiak	137 34 04.78	317 26 40.55	4.28175

BILLY CREEK, NEZ PERCES COUNTY.

On a high mountain spur running out from the Billy Creek range, about 30 miles southeast from Lewiston and 5 miles east of Snake River.

Station mark: The lone pine signal tree.

[Latitude 46° 05′ 27.59″. Longitude 116° 52′ 57.51″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Anatone	93 54 05.32	273 38 04.46	4.46123
Windmill	133 32 29.72	313 24 47.81	4.27744
Snake	156 11 17.75	336 00 52.15	4.66027

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PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 216.]

The publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

NOTES

ON THE

GEOLOGY OF SOUTHWESTERN IDAHO AND SOUTHEASTERN OREGON

BY

ISRAEL C. RUSSELL

WASHINGTON
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NOTES ON THE GEOLOGY OF SOUTHWESTERN IDAHO AND SOUTHEASTERN OREGON.

By ISRAEL C. RUSSELL.

INTRODUCTION.

During the summer of 1902 I made a rapid reconnaissance through portions of southwestern Idaho and southeastern Oregon for the purpose, principally, of ascertaining in what localities, if any, the geological conditions are favorable to obtaining flowing water by drilling wells. This search was more successful than had been hoped, and a preliminary report on the artesian basins discovered has already been published.[a] The explorations referred to were in continuation of similar work done the preceding summer in southern Idaho, a report on which was published as Bulletin No. 199 of the United States Geological Survey. The aim of the present paper is to put on record such observations relating to the general geology of the region traversed as it is thought may be of interest, more particularly to the people of Idaho and Oregon, and also in certain instances serve to supplement the report referred to on artesian conditions.

During the reconnaissance I was assisted by Mr. Scott Turner and Mr. Robert H. Dawson, students of the University of Michigan. Our journey began at Boise, Idaho, on July 6, and ended at the same place on September 6, 1902. The route followed was planned so as to traverse as many as possible of the valleys of southwestern Idaho and southeastern Oregon, in which rich agricultural land is plentiful and where artesian conditions are most likely to be present. Portions of Canyon and Owyhee counties, Idaho, and of Malheur and Harney counties, Oreg., were examined; but it is not to be understood that anything like a geological survey of the immense territory included in these counties was undertaken. This paper is simply an account of observations made during a rapid reconnaissance, principally in the way of supplementing the study of artesian conditions, and should not be judged in any other light.

[a] Water Sup. and Irr. Paper No. 78, U. S. Geol. Survey, 1903.

CLIMATE AND VEGETATION.

The leading characteristics of the climate of the portions of Idaho and Oregon here considered are: Small precipitation; generally cloudless skies; hot, dry summers; and moderately cold winters, during which there is some rain and snow, but not enough to make the mean annual precipitation large. Something of the nature of the prevailing climatic conditions may be judged from the following data, compiled from the report of the United States Weather Bureau for 1900, which pertain to localities within or near the region here discussed.

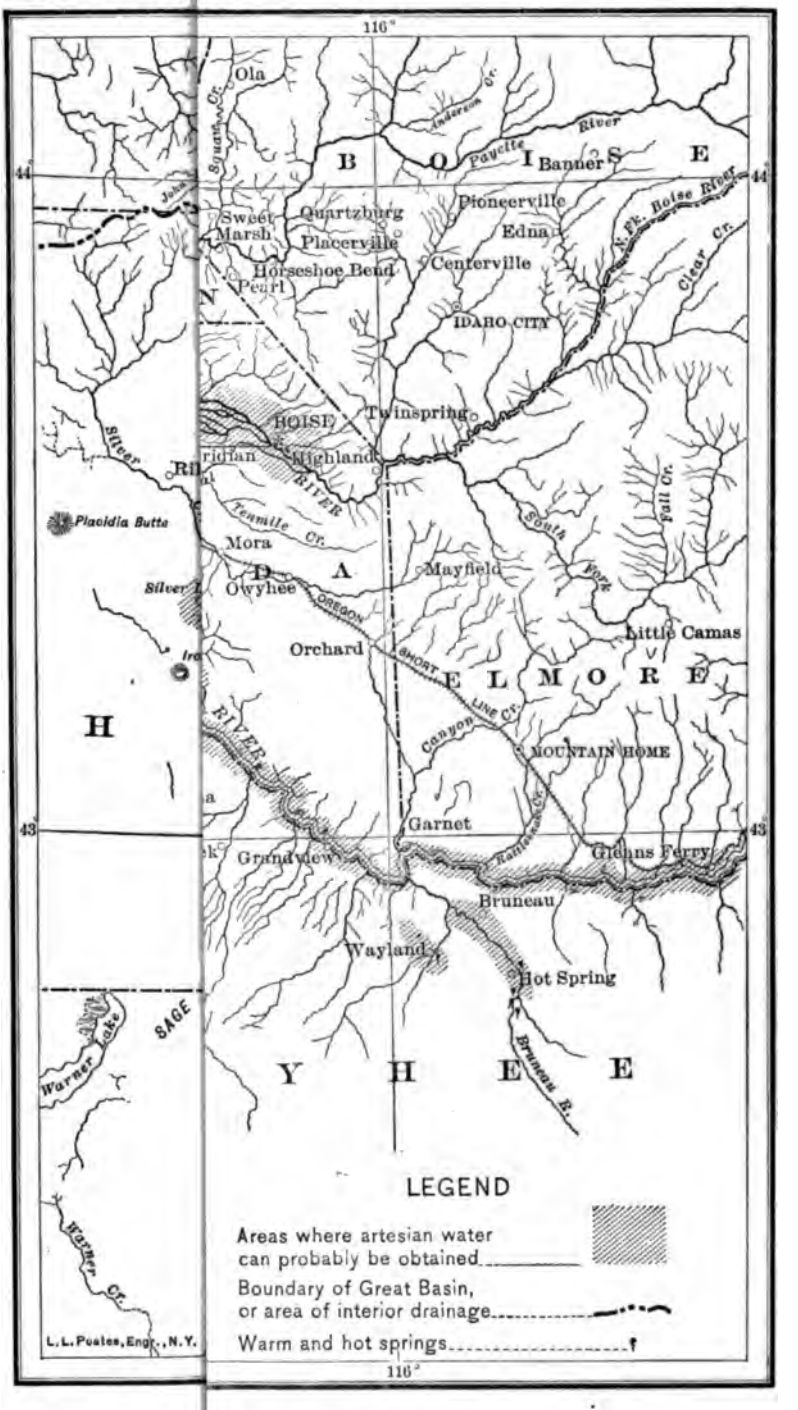
Weather records for the year 1900.

Locality.	Precipitation.	Temperature.			Killing frost.		Snow.
		Minimum.	Maximum.	Mean.	Last in spring.	First in autumn.	
	Inches.	*Deg. F.*	*Deg. F.*	*Deg. F.*			*Inches.*
Boise, Idaho	12.77	11	104	52	Apr. 23	Oct. 23	20.1
Garnet, Idaho	8.11	14	.....	.....	Apr. 26	Oct. 25	.....
Payette, Idaho	10.60	10	104	53.7	Apr. 13	Sept. 25	19.8
Baker City, Oreg	13.84	−1	95	47.3	May 29	Sept. 26	27.8
Burns, Oreg	6.57	1	99	46.1	May 16	Aug. 8	.....
Silver Lake, Oreg	7.34	0	98	46.4	(a)	(a)	12.8
Vale, Oreg	9.21	8	101	49.4	May 26	Sept. 18	15.5

[a] Temperature below 32° F. every month.

All the localities mentioned in the above table are situated in valleys. On the mountains cooler and more humid atmospheric conditions prevail. The snowfall is light in the valleys and, like the mean annual precipitation, increases with elevation, but not in a direct and simple ratio. The general climatic conditions of both Idaho and Oregon vary in a conspicuous manner at different localities. In Idaho the northern and more mountainous portion of the State is much colder and more humid than the intensely arid southern portion. In Oregon aridity is the prevailing condition in the southeastern and central parts of the State, with increasing humidity toward the west and northeast. The portion of each State here described, while characteristic of its most arid valleys and most desolate mountains, must not be considered as representative of the entire political division of which it forms a part.

The most conspicuous effect of increase in elevation on climatic conditions in the region discussed is an increase in precipitation, particularly in snowfall. While in spring and early summer the snow lingers on the mountains long after it has disappeared from


116°
44°
43°
Ola
Squaw Cr.
Anderson Cr.
Payette River
B O I S E
Banner
Pioneerville
Sweet
Marsh
Quartzburg
Placerville
Horseshoe Bend
Pearl
Centerville
Ednah
N. Fk. Boise River
Clear Cr.
IDAHO CITY
Twinspring
BOISE
Highland
RIVER
Silver
Placidia Butte
Tenmile Cr.
Mora
D A
Owyhee
Mayfield
South Fork
Fall Cr.
Silver L.
OREGON
SHORT LINE Cr.
Orchard
Little Camas
E L M O R E
H
RIVER
Canyon
MOUNTAIN HOME
Garnet
Grandview
Ranchero Cr.
Glenns Ferry
Bruneau
Wayland
Hot Spring
Bruneau R.
Y H E E
SAGE
Warner Lake
Warner Cr.
LEGEND
Areas where artesian water can probably be obtained
Boundary of Great Basin, or area of interior drainage
Warm and hot springs
L. L. Poates, Eng., N.Y.

the valleys, there is but one mountain range in the region on which it remains throughout the year. On Stein Mountain, Oregon, snow banks occur in the shelter of northward-facing cliffs in midsummer, and severe snowstorms occur as late as the first week in July and as early in the autumn as the middle of September. It is principally the melting of the usually abundant snow on this mountain range that feeds the many streams which flow from it into the adjacent valleys.

On account of the small rainfall in the valleys, agriculture is impracticable without irrigation. Throughout much of the region agricultural pursuits are restricted also on account of the liability of frost, particularly in the more elevated valleys where other conditions, such as the composition and texture of the soil are favorable.

At one time both valleys and mountains throughout southern Idaho and adjacent portions of Oregon were clothed with nutritious bunch grass, but now to a great extent these natural pastures are nearly ruined, owing to overgrazing. The valleys are treeless, except for the occasional cottonwoods along the immediate margins of streams, and the hills and lower mountain slopes are for the most part devoid of timber.

Throughout southern Idaho and over the greater portion of Oregon east of the Cascade Mountains, the plant which is most characteristic is the sagebrush (*Artemisia*). In common with nearly all of the arid region of the United States, the area discussed is a sagebrush land. At no locality along the route traveled is one beyond recognizable distance of this ubiquitous grayish-green shrub, except while crossing the barren mud plains left by the desiccation of ephemeral lakes or while standing on the summit of Stein Mountain. Although the sagebrush imparts a dreary monotony to the valley and lower mountain slopes, every traveler who lives out of doors is indebted to it for fuel. Not only does the sage replenish the explorer's camp fire, but to a considerable extent it is the ranchman's wood pile. Where it grows sturdily there is rich land, which needs only irrigation to make it highly productive.

The first tree to make its appearance when increase in elevation brings about greater precipitation is the juniper. Mingled with the scattered juniper trees, and usually beginning at a somewhat greater elevation than their lower limit, are thickets and groves of mountain mahogany. These grayish-green trees when growing wide apart frequently attain a height of 20 to 30 feet and look not unlike olive trees. They add much to the beauty of the land, or, perhaps more accurately, detract in a marked way from the desolation of the lower mountain slopes. In the deep stream-cut valleys they frequently form almost impenetrable thickets. On many of the lower mountains, as Mahogany Mountain in Oregon, for example, they constitute almost the only arboreal vegetation. Above the lower limit of the juniper

and the mountain mahogany in certain favored ranges pines and firs appear and occasionally form valuable forests. The scarcity of trees throughout the arid portions of the two States visited is indicated by the fact that along the route traveled pines and firs are only seen at a distance. It is almost literally true that a traveler over the route referred to, about 600 miles in length, is never beneath the shade of a tree, unless it is one which has been planted and irrigated. The Lombardy poplar is usually chosen as a shade tree in villages and about farm houses and to serve as a wind-break on the borders of orchards and gardens. So adverse to tree growth are the climatic conditions that in the region covered by the reconnaissance there are only two areas to be seen which are dark with forests.

Castle Rock, a prominent crag situated in the northwest portion of Malheur County, Oreg., is on the southern border of an extensive forest of pines, firs, juniper, mountain mahogany, and other trees, and from its commanding summit the mountains to the northwest are seen to be black with evergreens. In autumn the somber tone of the mountains is relieved by dashes of golden yellow, mostly in the gulches on the lower mountain slopes, which mark groves of aspens. Again, from the hills and mountains near Harney and Burns, in Harney County, Oreg., a splendid forest may be seen mantling the gradually ascending mountain to the northwest. It is in this extensive forested region that Silvies River has its source. One of the most noticeable features of this forest, a part of which has recently, and very judiciously, been set apart as a forest reserve, is the absence, so far as can be judged from distant views, of burned areas within it. On account of the remoteness of the forests of eastern Oregon from railroads, they have not as yet been encroached upon by lumbermen and still preserve their primeval beauty.

One interesting feature in connection with the distribution of trees on the mountains which rise from an arid region is the occurrence in certain instances of two "timber lines." There is an upper limit of timber growth, the true timber line, the position of which is determined principally by the severity of the climate and especially by the prolonged cold and icy gales of winter. There is also a lower limit, determined principally by lack of moisture, below which trees are absent. Each of these borders of the mountain forests is in many instances sharply defined. On lofty mountains surrounded by arid valleys, when seen from a distance, there is frequently present a dusky band appearing not unlike the shadow of a cloud, midway up their rugged slopes. The band of shade crosses bold crests and deeply sculptured valleys, but on both its upper and lower margins is somewhat more extended in the gorges and ravines than on the intervening ridges. The upper limit of tree growth, or the "cold timber line," as it may be termed, as is well known, declines in elevation when traced from equatorial toward polar regions.

In Mexico the upper limit of tree growth has an elevation of about 17,000 feet; in California it has an elevation of approximately 12,000 feet; on the slopes of Mount St. Elias, in Alaska, it is at an altitude of 2,500 feet; while in northern Alaska and northern Canada it reaches sea level. In the far North it becomes the continental timber line, and to the north of it are the treeless barren-grounds and tundras. The lower limit of tree growth, or the "dry timber line," is highest where the climate is most arid, and becomes lower and lower when traced to regions enjoying greater humidity.[a] In regions where precipitation in the valleys is too scanty to permit trees to grow, the mountains may perhaps rise above the lower or dry timber line and become forest clothed. If the mountains are sufficiently lofty, they may rise above the upper timber line, in which case their summits will be bare of trees, but perhaps rendered glorious by fields of gorgeous alpine flowers. In regions of extreme aridity the lower limit of tree growth, as determined by aridity, may be so high that it meets the similar upper limit, as determined by temperature, and even the most lofty mountains will be bare of trees from base to summit. A conspicuous illustration of the rise of the lower limit of tree growth until it meets the upper limit at which arboreal vegetation can survive is furnished by the White Mountains in western Nevada, which, although over 13,000 feet high, are bare of trees from base to summit. In general, then, the mountains of the arid region in west-central North America, of which the portions of Idaho and Oregon under consideration form a part, are in many instances bare of trees because they fail to reach above the dry timber line; others, in general more lofty, are encircled with a belt of forest; while still others, perhaps even higher than those having a belt of trees between the two timber lines, are barren, for the reason that the dry timber line rises until it meets the cold timber line.

These conditions are well illustrated in southeastern Oregon. The mountains northwest of Harney and Burns, probably from 5,000 to 7,000 feet in elevation, are clothed with a fine forest of pines and other coniferous trees, while Stein Mountain, about 100 miles distant to the southeast, and rising to an elevation of over 9,000 feet, is, with the exception of scattered groves in the deeper canyons, without trees. The mountains northwest of Burns and Harney are sufficiently lofty to reach above the lower limit of timber growth or the dry timber line, and on their higher portions are completely forest clothed, but do not have bare peaks rising above the cold timber line. Stein Mountain is bare at the summit on account of severe climatic conditions, and the region from which it rises is so arid that the dry timber line meets the cold timber line, and even an encircling belt of forest is ab-

[a] There is another condition which at times becomes dominant in limiting the distribution of trees, namely, excess of humidity, as on the borders of swamps, lakes, etc., and it may be found convenient to recognize a "wet timber line" in addition to those referred to above.

sent. On Stein Mountain a few pines, firs, junipers, and cottonwoods grow in the deep canyons on its western slope, and at a few localities along the border of the small streams which descend its precipitous eastern escarpment. In each of these instances the elevation is well below that of the cold timber line, and water for natural irrigation is supplied by streams.

The snow line on mountains, or the lower limit of perennial snow, like the upper and lower limits of arboreal vegetation, is determined by climatic conditions, mainly temperature. The snow line marks approximately the elevation at which the mean annual temperature is at the freezing point, namely, 32° F. The snow line, like the cold timber line, is high above the sea in equatorial regions, and declines toward the poles. In the Andes, near the equator, the snow line has an elevation of about 17,000 feet; in the high sierra of California, it is at an altitude of about 14,000 feet; on the southern slope of Mount St. Elias it has an elevation of 2,500 feet; and in the Arctic Archipelago it reaches sea level. The snow line is higher than the cold timber line, and between the two lies the belt of alpine flowers.

In southwestern Idaho and adjacent portions of Oregon none of the mountains are sufficiently lofty to reach the snow line, although Stein Mountain, the highest and finest range of the region, makes a near approach to the necessary height, and, as already stated, snow banks are found on its higher portion throughout the summer, but for the most part only in the noontide shadow of northward-facing precipices.

TOPOGRAPHY.

The portions of Idaho and Oregon under consideration have broad and, in general, flat-bottomed valleys, separated by abrupt and deeply sculptured hills and mountains. The valleys so situated that the streams formed in or traversing them can discharge into lower valleys or join Snake River are usually trenched by stream channels and canyons, but the valleys from which there is no escape of the surface water are level floored and either contain lakes or the desiccated beds of transient water bodies. The valleys for the most part owe their existence to the upraising of the bordering hills and mountains. Their generally flat bottoms are due to the breadth of the folds or irregular dome-like elevations and depressions resulting from movements in the rocks and to the partial filling of the depressions by lacustral and stream-deposited débris.

The greatest valley of the region is the one through which Snake River flows. This, as was described in a previous report,[a] extends from east to west across the entire width of southern Idaho, and includes an area of about 1,200 square miles in Malheur County, Oreg. This valley, known also as the Snake River Plains, is underlain by lacustral and stream deposits and by extensive sheets of basaltic

[a] Bull. U. S. Geol. Survey No. 199.

lava. The fine, light-colored sediments, mostly of Tertiary age, are best developed in southwestern Idaho and the adjacent portion of Oregon, while the associated lava sheets are more continuous and apparently more numerous in southern Idaho east of Ada County. This difference in the rocks is accompanied by marked contrasts in the topography. The vast smooth plain through which the Snake River flows has been deeply trenched by that river from American Falls westward, and where the walls of its canyon are of basalt they stand in bold cliffs, and if sedimentary beds are present beneath a surface sheet of basalt, there occurs along the borders of the plateaus a characteristic feature common in many areas in Oregon. The sheets of resistant material, with weak strata beneath, give origin to rim rocks, as they are locally termed; that is, precipitous and frequently vertical escarpments, surmounting more gentle slopes which are sheathed with débris derived from the crumbling margin of the protecting layer (Pl. XVI). The details in the valley sides present great variety, dependent on the number of alternating strong and weak beds, and their variations in thickness. Where the strong, resistant rocks greatly predominate, the valley sides due to erosion are bold, and if canyons have been excavated they are characteristically narrow, with nearly vertical walls. Where weak, easily eroded rocks predominate, other conditions being the same, the valleys are wide and have flaring sides, perhaps with a few vertical steps, marking the positions of resistant beds, and narrow canyons with vertical walls are absent. Where all the rocks cut through in the excavation of a canyon or valley are soft or weak, as for example where lava sheets are absent, and only lacustral beds, stream deposits, or beds of volcanic dust and lapilli are present, the valleys have widely flaring sides which are sculptured into a great variety of details, owing to the action of rain, rills, and usually ephemeral streams. The results just indicated, which depend mainly on rock texture and composition, or perhaps more strictly on the varying degree of resistance rocks offer to mechanical and chemical erosion, are modified, as is well known, by differences in the way the earth's surface is being sculptured, dependent on climatic conditions, elevation above sea level or the base-level of erosion. In the portions of Idaho and Oregon under consideration the climatic conditions are essentially the same throughout, but the elevation and the position of the rocks are markedly different from locality to locality.

MOUNTAINS.

The entire region here considered may be designated as mountainous, and although at present not enough is known of the underlying structure to permit a detailed description of the manner in which even the more prominent elevations were produced, it is apparent that two types of mountains are present.

The Owyhee Mountains, in southwestern Idaho and the adjacent portion of Oregon, consist of a broad dome-shaped mass, composed of sheets of igneous rock and thick deposits of Tertiary lake and stream sediments, but as indicated by the débris in the stream beds leading away from the central part of the extensive uplift, quartzite and granitic rocks are present in its higher portion. The great dome, from a cursory examination of a part of its bordering slopes, has been deeply dissected by streams and given a rough surface.

Similar to the Owyhee Mountains in their general features are the mountains of the northern portion of Malheur and Harney counties, but too little is known of that region to permit one to speak with confidence, even of the larger features in the structure. It is evident, however, that great erosion has taken place, and that all the secondary features, or those which give diversity and picturesqueness to the scenery, are due to the weathering of the uplifted rocks and the erosive work of streams.

Mahogany Mountain, in the east-central portion of Malheur County, Oreg., is a long, narrow, sharp-crested ridge, trending northeast and southwest, and presenting a bold escarpment to the northwest and a much more gentle, but still steep slope to the southeast. The rocks of which it is composed are to a considerable extent, at least, rhyolitic tuffs, which occur in well-stratified beds and are resistant to the agencies of erosion. Beneath the beds of tuff there are probably soft Tertiary lacustral and stream deposits, and the entire series is inclined downward to the southeast at angles varying from perhaps 10° to 15°. In short, this uplift has the characteristics of the Basin ranges of Utah and Nevada, and, as appears from the evidence in hand, may be considered as a ridge produced by the upheaval and tilting of the rocks on one side of a break; that is, the mountain is due to the tilting toward the southeast of an elevated fault block. Erosion has roughened the slopes of the mountain, but not enough to conceal the leading features due to uplift. It is clothed with picturesque groves of mountain mahogany, whence its name.

The most prominent mountain in eastern Oregon, and by far the most conspicuous of all the elevations of a region embracing many thousands of square miles in Idaho, Oregon, and Nevada, is Stein Mountain, in the southeastern portion of Harney County. This conspicuous uplift rises to a height of about 9,000 feet above the sea, by aneroid measure, and about 5,000 feet above the desert plain in Alvord Valley at its east base. It is a long, narrow range, trending in general about northeast and southwest, but its crest line is somewhat curved. On the east, in its highest and most characteristic portion, it presents a remarkably bold escarpment, and on the west it slopes gradually down to the valley in which Harney and Malheur lakes are situated. The crest line of the uplift is near its eastern border, the descent on the east being precipitous and seemingly

almost vertical, while the west slope, from 20 to 30 miles in length, has an inclination varying from about 3° at the crest line of the mountain to less than 1° at a distance of 15 miles, and continuing to decrease still farther westward. Southwest of the highest portion of the uplift the rocks of which it is composed are bent into a broad, gentle syncline that widens out to the northwest and passes beneath Harney and Malheur lakes. The longer axis of this synclinal trough pitches to the northwest and the inclined basin produced by the faulting and folding is drained by Donner and Blitzen River.

Stein Mountain is thus a typical monoclinal block of large size. The entire length of the uplift is in the neighborhood of 100 miles, but its extremities have not been closely examined. It is apparent that the main part of the eastward-facing cliff, forming the highest portion of the uplift for a distance of over 20 miles, is a fault scarp, along the base of which recent movements have taken place, as is indicated by the occurrence of hot springs and fresh breaks in alluvial deposits. During a visit to this region in 1882[a] I believed this fault to continue far to the north, but more detailed study must be made before this can be considered as fully established. It may be that at the north the Stein Mountain fault scarp merges with a similar eastward-facing cliff, which may be interpreted as being due to the erosion of an anticline. To the east of the great line of cliffs referred to there are other monoclinal ridges, which, so far as the evidence now in hand is concerned, may be interpreted as remnants of a deeply eroded anticline, instead of evidence of extensive faulting, as previously considered.

The rocks of which Stein Mountain is composed are principally basalt, in well-defined sheets. The basalt, as is well known, was poured out in a molten condition, either from fissures, forming what are termed massive eruptions, or, what is more probable, from well-defined volcanic vents, as has happened in many instances in the same general region in recent times. The age of the Stein Mountain basalt is probable Middle Tertiary, and it seems to be a part of the great succession of widely extended lava flows, termed in a general way the Columbia River lava. In the highest and grandest portion of the mountain the layers of basalt are in many instances separated one from another by layers of coarse yellowish sandstone, varying in thickness from 4 or 5 to about 15 feet. In one section, obtained while climbing the east face of the uplift, which overlooks Alvord Desert, seventeen of the sheets of sandstone referred to were observed. The basaltic layers average perhaps 60 to 75 feet in thickness, and a large number are present. The entire thickness of the great pile of widely extended sheets of basalt is about 5,000 feet.

On the west side of Alvord Desert, and for a distance of about 10

[a] Russell, I. C., A geological reconnaissance in southern Oregon: Fourth Ann. Rept. U. S. Geol. Survey, 1884, pp. 431-464.

miles along the east base of the highest portion of Stein Mountain, there are fine exposures of sedimentary rock, mostly shale, beneath the basalt composing the main mass of the mountain. These sediments have not, as yet, yielded fossils, but are probably of early Tertiary age. Their exposed thickness is over 1,000 feet. On the west side of Stein Mountain, in the vicinity of the east borders of Malheur and Harney lakes, there are, again, good exposures of sedimentary rocks and of tuff, but these are younger than the Stein Mountain basalt. A detailed study of this region can not fail to furnish most instructive results as to the succession of rocks which underlie a great portion of eastern Oregon and the neighboring parts of Idaho and Nevada, as well as typical illustrations of the manner in which the earth's crust throughout the same region have been bent and broken and otherwise deformed.

Traversing the immensely thick succession of basaltic sheets, in the east face of Stein Mountain, there is a number of nearly vertical basaltic dikes, ranging in thickness from about 15 to 60 feet. These dikes are horizontally columnar in their central portion and are well exposed in several instances for distances of a thousand feet or more in the walls of nearly vertical cliffs. These dikes, as is well known, are due to the filling of fissures with molten rock injected from below. The slow cooling of the intruded magma resulted in producing joints which define the sides of the usually six-sided, horizontal columns, which forms such a conspicuous feature of the parts of the dikes now exposed. The horizontal columns appear not unlike the steps of great stairways in the walls of the cliffs traversed by them, and a person climbing the mountain finds it convenient to utilize them as stepping stones, since in some instances they furnish the easiest means of ascent.

Since the upheaval of Stein Mountain it has undergone a large amount of erosion, and deep canyons have been excavated in it, especially on its western side. From the head of Donner and Blitzen River northward to Kieger Creek, a distance of about 25 miles, each of the principal westward-flowing streams, six in number, is situated in a deep canyon of its own making. The boldest and most characteristic of these excavations is the one occupied by Kieger Creek. This creek has its ultimate source at the crest line of the uplift, which, it will be remembed, is on the east margin of the tilted block forming the mountain, and flows westward in a steep-sided canyon that for a distance of about 8 miles is over 2,000 feet deep. The walls of this canyon, like all the other profound trenches cut in the west slope of the mountain, have been excavated in gently dipping beds of basalt. None of the westward-flowing streams, however, so far as known, has cut through the basalt so as to expose the rocks on which it rests. The canyon of Kieger Creek exhibits well-marked contrasts on its two sides. The north wall is a continuous and

remarkably smooth escarpment of basalt, concealed in large part by talus, while the south wall is broken by several deep alcoves or side canyons, between the mouths of which there are prominent and in some instances remarkably picturesque pinnacles and buttresses of black basalt. The scenery of the south wall is remarkably fine, and derives its principal geological interest from the fact that the bottoms of the side alcoves open out into the main canyon to which they are tributary, at a generally uniform horizon, at least 800 feet above its bottom. To use a name recently introduced into geographical literature, the alcoves referred to are hanging valleys, or valleys which have been occupied by and owe their leading characteristics, as is now generally conceded, to the work of small glaciers tributary to a much larger ice stream. The main canyon of Kieger Creek is broad bottomed, with a well-defined U-shape in cross section, due in part, however, to steep talus slopes on its side. In brief, the shape of the canyon is such as is usually attributed to the work of a stream-like glacier. There is an absence of well-marked lateral moraines on the canyon's sides, and no polished or striated rock surfaces were observed. In spite of the incompleteness of the records, however, it seems safer to conclude that the canyon was occupied at one time by a small glacier of the alpine type. Four or five small tributaries joined the main glacier on its south side, each one being situated in a lateral alcove about 1 mile in length. These lateral alcoves have the characteristic shapes of glacial cirques, and at the head of each one snow banks at the present time are found throughout the summer. With but a slight change of climate, prolonging the winter conditions and increasing the snowfall, these lateral alcoves would again be occupied by glaciers. There is an absence of glacial records on the bold summit portion of the mountain between the deep canyons trenching its gentle west slope, and it appears that even during the Glacial epoch the balance of atmospheric conditions was only favorable to the accumulation of snow to such an extent as to supply small local glaciers in the deeper valleys. Evidently the mountain was deeply trenched by the westward-flowing streams before the Glacial epoch, and the canyons excavated at that time were subsequently modified in a small way by glacial ice. None of the canyons referred to, excepting the one excavated by Kieger Creek, was closely examined, but from the descriptions given by residents of the region it seems that several of them, including the one in which the principal tributary of Donner and Blitzen River rises, may have been modified somewhat by glacial ice. Stein Mountain, it will be remembered, is an isolated uplift, and the highest elevation in eastern Oregon or the neighboring portions of Idaho and Nevada. It is also the only mountain in that great region, so far as we now know, that bears evidence of having been formerly occupied by glaciers.

VALLEYS.

The valleys of southern Idaho and southeastern Oregon are in general broad with nearly flat bottoms and either trenched by stream channels or smooth from side to side. The features due to stream erosion are found in the valleys which have an avenue of escape for their waters, such, for example, as discharge to Snake River, but some of those which are not completely inclosed are, on account of the aridity of the climate, not scored with stream-cut channels. The smaller streams from the uplands, on entering a valley, flow less rapidly than in the upper portions of their courses owing to the flattening of their channels. More than this, evaporation decreases the flow, and furthermore, also, as the streams enter the arid valleys soil moisture becomes less and there is percolation away from a stream channel instead of into it, as is normally the case in humid regions. For these various reasons the streams drop a large part and in many instances all of the material they bring from the uplands, and thus broaden the valley bottoms and tend to give them even surfaces. The material brought out of the usually narrow valleys and canyons in the uplands and spread over a wide area in the valleys ranges in physical character from coarse gravel and even large stones and bowlders to fine sand and the finest of silt. The coarser material is deposited for the most part near the base of the bordering uplands, but under exceptional conditions sometimes is carried far down the stream channels, while the finer material, owing to the subdividing of the streams in the valleys, and the presence of distributaries on alluvial cones, is spread out over a broad area. By this process deep accumulations have been formed over the valley floors. It is to this method of deposition that the richness of the soils in the valleys of Idaho and Oregon, in common with nearly the entire arid region, is due. The streams from the uplands which fail to reach through drainage lines to the sea not only deposit their visible loads of sand, silt, etc., but their invisible loads as well—that is, the material they bring from the higher portions of their courses in solution. This process is carried on not only by the ephemeral streams, but to a considerable extent, as is well known, by the perennial streams, since the latter, while flooded, in many instances widely overspread their dry-season channels.

In southwestern Idaho and in the northern portion of Malheur County, Oreg., the broader valleys are to a great extent floored with fine, nearly white silt and volcanic dust—the sediment of Lakes Idaho and Payette—deposited in Tertiary time, and in these instances it is sometimes difficult to distinguish the older deposits from the stream-deposited silts laid down on them at a later date. In fact, the material in each instance, to a considerable extent, is essentially the same, since modern streams have eroded the Tertiary terranes and redeposited the loads thus acquired on adjacent surfaces.

Throughout many of the valleys of southeastern Oregon the under-

lying formation is fine silt and volcanic dust, essentially the same as the material just referred to as having been deposited in Lakes Idaho and Payette. Conspicuous examples of such deposits occur in the valley of the Owyhee where Jordan Creek enters it, about the eastern and southern margins of Malheur and Harney lakes, and in many other localities. The picturesque badland sculpturing of the lacustral deposits in the valley of the Owyhee is represented on Pl. XVIII.

In general, as may be gathered from the statements just made, the valleys of the region examined are floored with the deposits of Tertiary lakes and by modern alluvium washed in from the adjacent uplands. Another process of filling is through the action of the wind. Considerable removal and redeposition of fine material is now going on, and in certain localities notable accumulations of sand and dust can be easily traced to this cause. Still another process of valley filling, which results in giving depressions remarkably level and conspicuously persistent surfaces, is by the accumulation of rock fragments, such as lapilli and volcanic dust blown out of volcanoes during explosive eruptions, and the overflow of highly liquid lava from volcanic vents, as will be explained later in describing some of the recent volcanoes of the region under consideration.

The wide distribution of fine alluvium over valley floors by ephemeral streams necessitates a delicate adjustment of climatic and topographic conditions such as is seldom seen except in regions of small rainfall. Before man disturbed the balance of natural conditions, many of the valleys of Idaho and Oregon became deeply filled with fine, usually yellowish or nearly white rock débris, and only faint stream channels, if any at all, could be distinguished on the surfaces of the deposits during the seasons of extreme desiccation. The uplands and valleys alike were clothed with an open growth of vegetation, consisting largely of bunch grass. On the uplands and hillsides the grasses serve to bind the soil together, but less completely and efficiently than is usually the case in humid regions where a continuous sod is present. In the valleys, owing to the absence in many instances of stream channels in the deep alluvium, soil moisture was held near the surface at least during a considerable part of the dry season, and grasses, notably the coarse rye grass, grew luxuriantly. This delicate balancing of conditions, a result of a long period of adjustment, was seriously disturbed when stock was introduced and grazing on the natural pastures was carried on extensively. The introduction of large numbers of sheep, especially, has resulted in the nearly complete destruction of the bunch grass over vast areas, and in consequence the surface run-off from the uplands has been rendered more rapid and rills have been formed where previously the rain water soaked into the ground and percolated slowly away. The more rapid surface run-off has caused the hillsides to be deeply gullied, much of the soil has been swept into the lowlands, and on account of the increased strength of the surface streams the débris

taken in suspension and redeposited is coarse as well as more abundant than formerly. Destructive denudation is thus in process on the hillsides and an equally destructive deposition taking place in the valleys. Owing to overgrazing the grasses do not have an opportunity to mature their seeds and scarcely to sprout from the old roots, and the destruction of the natural pastures is thus for several reasons going on at an accelerated rate. One result of the quicker transfer of the surface waters from the upland to the valleys is the excavation of channels, frequently from 5 to 20 feet deep, in valley floors, where, previous to the change referred to, the water spread out over the surface and deposited fine silt instead of eroding as at present. The cutting of channels has, in many instances, resulted in a far more complete subdrainage of the valleys, and in consequence has caused the disappearance of the rye grass which formerly flourished in them and its replacement by sagebrush. A conspicuous illustration of the process just outlined is furnished in the broad-bottomed valley of Willow Creek, northwest of Vale, in the northern part of Malheur County, Oreg. This valley, previous to the introduction of stock in excessive numbers, is reported to have been without a dry-season stream channel, and to have been clothed over great areas with a luxuriant growth of rye grass, which was mowed each year for hay. Now, owing to the more rapid escape of the rain water falling on the upland, a stream channel 8 or 10 feet deep has been excavated for a distance of a score of miles through the central part of the valley. In summer this freshly cut channel is dry and contains only occasional pools of water, and the rich land adjacent to it is so completely subdrained that the meadows of rye grass have disappeared and been replaced by sagebrush.

The cause for the recent changes just referred to is, as stated, overgrazing. The lands that have suffered, but more particularly the uplands, belong to the Federal Government, and are considered as free pastures. The reason for the ruin that has been wrought is the greed of the people owning stock. The remedy is the prohibition of free grazing on public lands. Now that practically all the land which can be irrigated, excepting through the use of artesian water and by the construction of storage reservoirs, such as can only be built by State or national aid, has passed to private owners, it seems desirable that the remaining land, and especially the hills and mountains, should be placed on the market at such a figure and under such conditions that they can be acquired in large tracts and cared for as private pastures. The beneficial influences of such a system are already shown, although illegally and in defiance of Federal laws, by the extensive tracts of Government land that have been inclosed with fences by numerous individuals and stock companies. If the grazing lands pass to private owners the interests of such owners would be to decrease and otherwise regulate the degree to which they are grazed, and to conserve and regenerate the rapidly vanishing grass crop.

HYDROGRAPHY.

DRAINAGE SLOPES.

In reference to drainage the portions of Idaho and Oregon traversed during the reconnaissance of 1902 present two principal divisions. All of the part of Idaho visited, together with Malheur County and the northeastern part of Harney County, Oreg., belong to the drainage system of Snake River, a branch of the Columbia, the waters of which are discharged into the Pacific Ocean. This region is thus a portion of the Pacific slope of North America. The principal part of Harney County, however, sends no water to the ocean, but is a part of the great region of interior drainage termed the Great Basin. The dividing line between these two great hydrographic provinces, in the region under review, is indicated by a broken line on the map forming Pl. I.

STREAMS.

The principal streams tributary to Snake River are the Owyhee and Malheur rivers. The Owyhee rises in the bold mountains of Owyhee County, Idaho, and the adjacent region on the west which lies in Oregon, and has the same general topography and climate. It flows for the most part through a succession of narrow defiles cut in resistant igneous rocks, but at times its canyon opens out into park-like valleys where soft lacustral sediment permitted easy excavation. One of these wide reaches eroded by the stream is situated where Jordan Creek joins it. Here there is a beautiful valley about 6 miles long and 2 miles wide, the east and west borders of which are picturesque cliffs. The rocks are principally evenly stratified lacustral sediments of Tertiary age which are light colored and in part of a delicate-green tint. Some idea of the marvelous rain and wind sculpture on the bold wall of this little stream-eroded basin may be gathered from Pl. XVIII. The bottom of the valley is sagebrush land, a small portion of which is now under irrigation. At the lower end of the valley the soft lacustral deposits are absent, and the river has cut a narrow canyon about 200 feet deep with vertical wall through dense igneous rock. A favorable site is here furnished for a storage reservoir, in which the abundant winter waters of the Owyhee might be retained for use on the parched plains near Snake River. This site is certainly worth careful investigation by engineers, and as I have been informed by settlers in the region, is but one of several similar localities along the Owyhee where storage dams might perhaps be constructed to advantage.

The Owyhee River, in the lower portion of its course, after passing through a narrow, irregular, steep-sided canyon in the Cedar Mountains and emerging into the broad valley excavated by Snake River, is bordered by flat lands, where the soil is rich. All of its water in summer is used for irrigation.

The Malheur River derives by far the greater part of its water from its branches, which come in from the northwest and have their sources in the forest-covered Strawberry Mountains. Its principal tributaries are perennial streams, but in summer all of the water which reaches the main channel is used for irrigation along the lower 40 miles of its course, and great areas of desirable land still remain uncultivated. As in the case of Owyhee, the Malheur demands careful study from hydraulic engineers, with the view of storing its winter flow for summer use.

A feature of special geographical interest in the case of the Malheur is the fact that it has lost fully one-third of its former drainage basin, owing, judged by the observations, to the occurrence of a lava flow which dammed its channel in the vicinity of Mule, in Harney County, between Stein Mountain and the Crow Creek Hills. It is to this lava dam, which obstructs the old river bed for a distance of about 30 miles, that Harney and Malheur lakes are due. The surface of the lava is only about 10 or perhaps 15 feet above the normal level of Malheur Lake, but the broad, flat-bottom valley to the west of the obstruction permits of the spreading out of the waters which reach it until evaporation counterbalances the inflow, and the lakes produced have never risen sufficiently to discharge across the lava sheet which retains them.

The portion of the former channel of Malheur River now floored with a sheet of recent lava is situated about 6 miles north of Mule, and leads from the broad basin of Malheur Lake eastward to Camp Creek, at present the extreme southern branch of Malheur River. The level-floored valley is about 1 mile wide near Mule, with bold bluffs on each side, and the essentially level lava sheet now forming its bottom is not broken by a stream channel until a point about 6 miles from Camp Creek is reached. Near the terminus of the lava stream its surface is rugged and presents numerous ridges like those so common in the Snake River Plains. The valley is treeless, but is covered with a strong growth of sagebrush.

The failure of Malheur Lake to rise and overflow the low lava dam which confines it is evidence that the climate of the region has been arid since the obstruction was formed. The ponding of the waters above the lava dam and their failure to rise and cross it caused the entire region now drained by Malheur and Harney lakes, about 4,500 square miles in area, to be removed from the Pacific slope drainage and added to the Great Basin.

The principal streams in the region draining to Malheur and Harney lakes are Silvies River, which rises in the forest-covered mountains to the north of Burns and Harney, flows south, and empties into Malheur Lake; and Donner and Blitzen River, which has its head branches on the west slope of Stein Mountain, flows northward, and also enters Malheur Lake. Of these two important streams, Silvies River is *much the larger.* Each of these streams is utilized to its full capacity

for irrigation, but there are seemingly favorable conditions for storing their abundant winter run-off and thus increasing their efficiency, not only for agricultural purposes, but as sources of power. Of the numerous small streams which rise on the elevated borders of the Malheur-Harney basin, and flow toward its center, there are none which reach the lakes in summer. Some of the small streams referred to, as Rattlesnake Creek near Harney, and Cow Creek, in summer barely enter the broad flat-bottomed basin to which they flow and there expand and are lost in natural meadows. In the majority of instances, however, the smaller streams from the mountains flow only during the rainy season or when the snow on the uplands is melting; they become dry in summer.

East of Stein Mountain there are several basins, aggregating about 1,500 square miles in area, from which there is no outflow of water. The largest of these is the one in which Alvord Desert is situated. Alvord, Mann, and Juniper lakes occupy other similar desert valleys. This region is a part of the Great Basin, and all the water which reaches it is evaporated. The streams are small and wherever land is available are fully utilized for irrigation.

Such information as I have been able to gather concerning Snake River and its tributaries, in the portion of its course represented on the accompanying map (Pl. I), is contained in Bulletin No. 199 of the United States Geological Survey. A much more detailed account of the river, however, and of the water resources generally of southern Idaho may be found in the reports of the State engineer of Idaho.

SPRINGS AND ARTESIAN WELLS.

Some account of the warm and hot springs and of the artesian wells in the portions of Idaho and Oregon examined in 1902 has been presented in a preliminary report on the work of that season,[a] and only a brief summary of the results reached in this connection seems desirable at this time.

It is to be understood that the streams briefly described above, like most streams the world over, are fed by rains or melting snow, but to a great extent owe their water supply to seepage from the bordering uplands. The seepage referred to is sometimes sufficiently concentrated at definite localities to form hillside springs, the temperature of which throughout the year is approximately the same as the mean annual temperature of the locality where they are situated. In the region under consideration this may be taken as approximately 50° F., although in certain localities, as at Burns, Oreg., it is perhaps 2° lower.

In addition to hillside springs, there are at numerous localities, as indicated approximately on the map (Pl. I), springs of warm or hot water, which rise from deep sources, presumably in most instances

[a] Water-Sup. and Irr. Paper U. S. Geol. Survey No. 78, 1903.

through fissures. These springs range in temperature from a few degrees above the mean annual surface temperature up to the boiling point of water for the elevation at which they occur, and vary in volume from a mere seepage to several cubic feet per second. Good examples are furnished in Idaho by the hot springs about 4½ miles east of Boise, the hot spring about 7 miles east of Mountain Home, the warm spring 1 mile west of Walters Butte, the copious hot spring at Enterprise; and the several springs of warm water near Sands. In Oregon hot springs occur at Vale, where one has a temperature of 198½° F., so far as known the hottest in the region; in Warm Spring Valley between Vale and Westfall; at Beulah; from 1 to 3 miles southwest of Burns; near Silver Lake; on the southeast border of Harney Lake; a few miles northeast of Malheur Lake; in Alvord Valley on the west border of Alvord Desert; near Andrews; and in Whitehorse Valley. Such data as are available concerning these numerous fountains of heated waters are presented in the Preliminary Report on Artesian Conditions,[a] already referred to.

The chief interest in reference to these warm and hot springs aside from their direct utilization for irrigation, baths, cooking, warming houses, etc., is the bearing they have on the question of obtaining artesian water. Every fissure spring is essentially a natural artesian well, but in most instances the conduits through which the water rises are obstructed and much lateral flow or leakage presumably results. The question as to the best way of improving such springs and of increasing their flow presents itself to everyone who examines them. In a few instances efforts have been made in this direction which are highly promising. Wells drilled in the vicinity of the hot springs near Boise have been conspicuously successful, and the capital of Idaho now has an excellent supply of both hot water—temperature from 125° F. to near boiling point—and of water with a temperature of from 60° to 70° F. derived from artesian wells. Other successful artesian wells have been drilled in the vicinity of hot springs in Bruneau and Little valleys, Idaho, and again at Vale, Malheur County, Oreg. The well at Vale is, however, not utilized except for bathing, on account of the large amount of mineral matter in solution, much of which is deposited in the casing of the drill hole and leads to its obstruction.

The water of this artesian well, or, perhaps more accurately, developed hot spring, should be analyzed in order to learn its medical or other properties, and experiments made with reference to preventing the precipitation of mineral matter. The precipitation is apparently due to the cooling of the water as it rises, and by insulating the casing this could no doubt be decreased and perhaps prevented. Then, too, if the waters prove of value, tools for cleaning the well could easily be provided and the obstructions formed within it removed as frequently as necessary.

[a] Water-Sup. and Irr. Paper U. S. Geol. Survey No. 78, 1903.

ARTESIAN BASINS.

The study of the geological structure—that is, the positions the stratified rocks occupy—together with the information furnished by springs and drilled wells, has shown that there are four basins in southwestern Idaho and southeastern Oregon which may be expected to yield flowing water when wells are put down. In two of the basins referred to drilled wells have already proved the presence of subsurface water under sufficient pressure to cause it to rise to the surface and overflow when the drill holes are properly cased. The four basins referred to have been described in the Preliminary Report on Artesian Conditions already mentioned, and are indicated approximately on the map forming Pl. I. They have been named the Lewis, Otis, Harney, and Whitehorse artesian basins. Their combined areas below the artesian head in each instance is estimated at approximately 2,000 square miles. While it is not to be assumed that all of this area can be irrigated by means of artesian wells, the conditions are such as to warrant the careful testing of each basin and a judicious development of its water supply.

The Lewis artesian basin, situated along Snake River, between Glenns Ferry and Weiser, and including Bruneau and Little valleys and the lower portion of Boise Valley, has an area below the known artesian head of not less than 1,000 square miles. Wells have been put down in it at several localities, as in Bruneau Valley, Little Valley, and near Guffey, Central, and Enterprise, in Idaho, and at Ontario, in Oregon. These wells are from 200 to somewhat more than 1,000 feet deep, and with one exception—near Central—are all successful so far as demonstrating the presence of artesian conditions is concerned, and in the majority of instances furnish a strong surface flow of water. The water in all cases in which temperature measurements have been made is warm and in general ranges from 60° to 100° F. The exceptional well at Vale, which is strictly speaking a developed hot spring, has a temperature of 198½° F. The artesian wells near Central and Enterprise exhibit an increase in their temperature gradients—that is, the rate of increase in temperature with depth—as the large hot spring at Enterprise is approached. This and other similar although less definite instances indicate that the Lewis artesian basin is supplied in part at least by water rising through fissures from a considerable depth.

The greater number of borings that have been put down in the Lewis artesian basin were drilled with the hope of obtaining petroleum. In this respect they were failures, although they attained a more desirable result in demonstrating the existence of artesian water. The reasons for the failure to discover petroleum and the conditions which lead to the accumulation of that substance will be discussed later.

The Otis artesian basin, in the region drained by Otis Creek, about 6 miles northeast of Drewsey, Oreg., has not been tested with the drill, and will merit the name here given it only after such demon-

tration. The reasons for predicting the presence of subsurface water under pressure are the basin-like structure the rocks exhibit and the presence within the basin of strong springs of warm water. The area throughout which it is probable that artesian water can be had is in the neighborhood of 20 square miles.

The Harney artesian basin embraces the extensive region draining Malheur and Harney lakes, and as shown by its geological structure may be expected to yield flowing wells throughout an area of perhaps 1,000 square miles. Two drill holes, one near Harney and the other near Burns, have been put down and have demonstrated the existence of subsurface water under sufficient pressure to force it to the surface where wells are drilled to the requisite depth and properly cased. The artesian head, as indicated by these wells, has an elevation of about 4,100 feet. The thickness of rocks involved in the formation of the basin, however, probably exceeds 10,000 feet, and water-bearing horizons at a greater depth than those now known may reasonably be expected to be present. Several warm and hot springs in the Harney basin, as already mentioned, lend support to the prediction that success will follow a careful exploration of the basin with the drill where the surface elevation is less than that of Harney or Burns.

The Whitehorse artesian basin is located about 20 or 25 miles east of the higher portion of Stein Mountain, and includes the valley in which the former military post known as Whitehorse was located. Here again the geological structure and the presence of warm springs are sufficiently strong indications to warrant a careful exploration with the drill with the hope of obtaining a surface flow of water. The artesian head, as shown by the warm springs about 6 miles south of Whitehorse ranch, is well above the flat lands of the valley's bottom. The area throughout which one is seemingly justified in predicting success in case wells are drilled is not less than 30 square miles.

The four artesian basins briefly described above contain about 2,000 square miles of rich agricultural land, throughout which the conditions justify the opinion that flowing water may be obtained. It does not follow from this that all or even the greater part of the tracts referred to can be irrigated, as it is to be presumed that the water supply will not be adequate to meet all the demands that will be made upon it. The expense involved in drilling a well, and the certainty that the water supply even under the most sanguine expectations which may seem warrantable is not inexhaustible, make it imperative that there should be the strictest economy in the use of the water and rigid restrictions with reference to its waste. Suggestions in this direction have been offered in the Preliminary Report on Artesian Conditions, to which the reader is referred for a more detailed record of the facts available concerning the artesian basins of the region under review and the best means to be employed in the development and care of their water resources.

LAKES.

As previously stated, the portions of Idaho and Oregon shown on the accompanying map (Pl. I) have undergone long erosion, since the youngest of the more extensive geological formations occurring there were spread out as lacustral sediments or lava flows, and during or since these same formations were folded and faulted. As a result of such a well-advanced stage in topographical development, the land would be expected to be well provided with drainage channels, cascades and waterfalls should be rare, and all lake basins should have been either filled with sediment or drained on account of the cutting of channels by their overflowing streams. These expectations are fulfilled throughout the greater part of the region referred to, and the exceptions are due to special occurrences which are seemingly accidents, and which have interrupted the normal course of events. The so-called accidents referred to are of two classes, namely, lava flows, and decrease in precipitation accompanied by an increase in the rate of evaporation. Locally conditions dependent on each of these causes have acquired control in the processes of stream erosion and denudation, and lakes appear in situations where they would otherwise be absent.

There are three localities in the region under consideration where lakes are present, all of which are in Oregon. These are on Cow Creek, a branch of Jordan Creek, in the eastern part of Malheur County, where the Cow Creek lakes are situated; the Harney Valley, in Harney County, which is occupied in part by Malheur, Harney, and Little Silver lakes; and Alvord Valley, also in Harney County, and east of Stein Mountain, where there are about 8 lakes during rainy periods, most of which evaporate to dryness during summer seasons.

COW CREEK LAKES.

In the valley of Cow Creek, about 12 miles northwest of Jordan Valley village, there are several small lakes, with markedly irregular outlines. These lakes are due to the damming of the waters of Cow Creek by recent lava flows. As will be described later, not less than four small volcanic craters of recent origin, which it is convenient to term the Jordan Craters, occur in what was previous to their formation a well-drained valley. The craters referred to are situated approximately on a north-south line, a little to the west of the former course of Cow Creek, and from each crater have been poured out what may be truthfully stated to be immense lava flows, in comparison with the size of the craters from which they came. Each of these flows acted as a dam to the waters of Cow Creek and led to the formation of one or more lakes. The most characteristic example of the lakes formed in this way is the most northerly in the series, which is held in check by the last lava flow from the Jordan Craters. This lava sheet has an

area of about 50 square miles and entered the channel which Cow Creek had eroded through a previous lava sheet. The recent lava flowed up the old canyon for about a mile and now terminates with a low, irregular slope. The lava forms a dam, above which a lake about 4 miles long has been caused to form. The lake extends into lateral valleys so as to have an irregular outline, but on an average is perhaps half a mile wide. During high-water stages it overflows across basalt and supplies other lakes to the south. In summer it is lowered by evaporation, leaving broad areas exposed about its eastern and northern borders. These lands are covered with wild grass, and form natural meadows from which several hundred tons of hay are cut each year. The lake has never been known to evaporate to dryness, and is only slightly alkaline. Its water, as is common with many playa lakes (that is, lakes which evaporate each summer so as to leave large portions, or as is most common, their entire beds, exposed as mud plains or playas), is always turbid with fine silt in suspension.

South of the lake just described, which is the largest of the series of which it is a member, there are seven or eight other similar water bodies and several small ponds. The irregularities of these lakes and ponds and their indefinite or rather variable number are due to the fact that the water fluctuates in volume, and as the surface of the lava, which is in part submerged, is irregular, marked changes in the outlines and in the number of lakelets to be seen occur between the rainy and dry seasons. The more southern of the Cow Creek lakes, like the one at the north, fluctuates greatly in volume, and in summer leaves broad natural meadows exposed on its eastern border, from which large quantities of naturally irrigated wild grass are cut each year. Cow Creek, south of the lakes in which it is ponded, flows through an irregular, ill-defined channel, and near Jordan Creek its waters are utilized for irrigation.

About the Cow Creek lakes the creek which supplies them flows through a rather deep canyon which is joined by well-defined branches, thus demonstrating that the process of stream adjustment and of erosion was well advanced before the Jordan Craters sent out lava which invaded the medial portion of the valley it entered, and buried its previous stream-sculptured surface.

The Cow Creek lakes furnish a fresh and unmodified illustration of the effects of lava flows on drainage, and present typical examples of lava-dammed lakes. Other lakes of the same character occur about the Diamond Craters, at the west base of Stein Mountain, in Harney County, but are much less extensive, and in fact swamps instead of open water mark the presence of obstructions to the escape of the surface waters. The Bowden Crater, as will be described later, also sent out a broad lava sheet, which obstructed the drainage and caused a lake to form, but in this instance the outflowing stream has cut a drainage channel, and the lake, which once existed, has been drained.

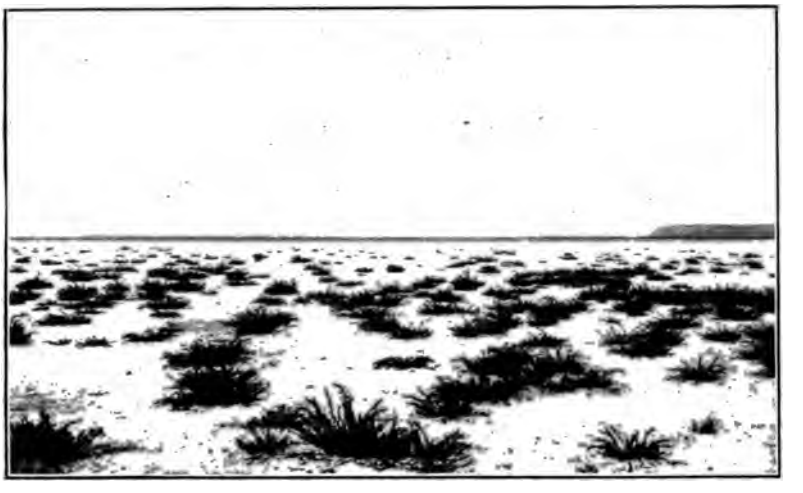
MALHEUR AND HARNEY LAKES.

These two water bodies, situated in the central part of Harney County, present several features of geographical interest. Harney Valley is situated in an arid climate and is one of the many valleys in the region of interior drainage termed the Great Basin which now fail to send streams to the ocean. Malheur Lake is flat bottomed, with low, indefinite shores, and although fluctuating greatly in area with seasonable changes in precipitation and the rate of melting of snow on the neighboring mountains, is probably at no time over 10 feet deep in its deepest part. When most broadly expanded it is about 23 miles long by 5 or 6 miles wide and has an area of approximately 135 square miles, but as it is bordered on nearly all sides with swamps, and large areas even in its central parts are occupied by rank growths of tules and other aquatic plants, its precise area would be difficult of determination even if surveys were made for that purpose. Its water supply comes mainly from Silvies River, which rises in the forest-covered mountains to the northwest and has a length, not including its minor bends, of about 75 miles, and from Donner and Blitzen River, the sources of which are on Stein Mountain, 50 or 60 miles to the southeast. Before their waters were utilized for irrigation these streams probably never failed, even in summer, to send a large volume of water to the lake. In addition, there are several streams which reach the lake only in winter, and a few springs, which add in a small way to the lake's resources.

Harney Lake, situated southwest of Malheur Lake, is rudely circular, with a diameter of about 10 miles and an area of from 50 to 60 square miles. Its northern and western shores are low and gently sloping, but the water line is well defined, and swamps are absent. On the southeast side of the lake cliffs rise precipitously from its margin during high-water stages, and near the shore the waters have a considerable though as yet unmeasured depth. Judging from the appearance of the lake when seen from adjacent hills, and from the ineffectual attempts to sound it made by fishermen, it is to be expected that a depth varying from 50 to 100 feet throughout a large portion of its central and southwest portions will be discovered when an accurate survey is made. A large volume of water is contributed to the lake by Silver Creek, which in midsummer, when its supply comes entirely from springs in the lower portion of its course, discharges about 10 cubic feet of water per second. In winter and spring Silver Creek is greatly extended headwards and becomes a drainage channel for a region 80 or 100 square miles in area. At such times it is a veritable river with a broad, swift current, and discharges a great volume of water into the lake at its mouth. There are also ephemeral streams which flow to Harney Lake during the rainy season, and hot springs on its border make some contribution to its water supply.

None of the springs rising in the neighborhood of Malheur and Harney lakes, it may be noted, are highly charged with mineral matter in solution, and all their tributary streams are of clear, sweet water, unless it is in late summer, when they are greatly reduced in volume by evaporation.

Malheur and Harney lakes are without outlet, except that during high-water stages the former sometimes overflows into the latter through a recently formed channel. The two lakes during their winter stages are separated by a narrow irregular ridge of sand dunes, which extends westward and borders Harney Lake for several miles. These dunes are composed of quartz sand, blown up from the shore of the lake during low-water stages by the prevailing westerly winds, and make a conspicuous range of hills in general about 100 feet high, in part grass covered, with steep-sided basins among them. Previous to the formation of these hills of wind-drifted sand the basins of Malheur and Harney lakes were not separated one from the other, at least during high-water stages, and but one lake existed. The water in this lake at the locality where the basin is now divided was shallow and during summer seasons, or at intervals of unusual desiccation, the bottom was exposed. During such a low-water stage, as seems evident, the winds drifted the exposed sands and formed a ridge which divided the preceding water body into two lakes. This was before white men visited the region. It is reported that during an unusually high-water stage in 1877, and aided, as I have been informed, by a furrow plowed for the purpose, the water of Malheur Lake broke across the ridge of sand referred to above and rapidly scoured out a channel leading to Harney Lake. This channel is now about a quarter of a mile long, 30 to 40 yards wide, and from 6 to 10 feet deep. At the time of my visit, August 6, 1901, the channel was dry and the water of Malheur Lake had shrunk until only a few hundred acres to the south of The Narrows (a constriction in the lake near its southern end, now crossed by a bridge) were flooded; the water of Harney Lake had also been diminished by evaporation so that the lake's surface was from 8 to 10 feet below the ridge of sand and gravel marking its preceding winter stage. The gravel ridge or beach line referred to was about on a level with the highest point in the newly formed channel, but the ridge, it will be understood, marks the upper limit of the waves generated during storms and not the usual level of the lake. In summer, when Malheur Lake is low, nearly the whole of the portion of its basin south of The Narrows is dry and converted into a playa over which broad areas are white with alkaline salts, or overgrown with the familiar plant of alkaline valleys known as *Salicornia* (Pl. II, *A*). Nearly every winter season, as I have been informed by persons living in the vicinity, Malheur Lake rises and overflows into Harney Lake. Each lake is alkaline, but, owing to the delicate adjustment described above, Harney Lake is more strongly charged with mineral matter in solution



A SOUTH SHORE OF MALHEUR LAKE, OREGON. SALACORNIA GROWING IN ALKALI.

B. EOLIAN MOUNDS ON BORDER OF PLAYA, NEAR IRON MOUNTAIN, OREGON.

than its companion which occasionally discharges into it. A sample of water from Harney Lake collected August 5, 1902, gave the following results on analysis:

Analysis of the water of Harney Lake, Oregon.

[Analyst, George Steiger.]

	Parts per million.
Silica, SiO_2	28.7
Aluminum, Al	None.
Iron, Fe	None.
Magnesium, Mg	6.8
Calcium, Ca	None.
Sodium, Na	3,604.5
Potassium, K	192.8
Carbon trioxide, CO_3	2,974.7
Hydrogen, H (required in formation of bicarbonate)	32.3
Sulphuric anhydride, SO_4	773.3
Chlorine, Cl	2,771.3
Bromine, Br	None.
Iodine, I	None.
Boracic acid, B_4O_7	92.8
Total	10,477.2

Specific gravity, 1.081.

NOTE.—Reaction strongly alkaline. The computation shows that no free carbonic acid is present above that required to form bicarbonates.

Judging from the analysis given above, the most abundant salts contained in the lake waters are sodium chloride or common salt, sodium carbonate or bicarbonate, and sodium sulphate. Potash and borax are present, but as the total amount of saline matter in solution is only 1.04 per cent by weight, the lake waters can not be considered as being of commercial value. The low degree of salinity, and the absence of iodine and bromine, together with the low percentage of magnesia, furnish evidence that the lake as it exists at the present day is not the result of a long period of concentration by evaporation.

The water of Malheur Lake is a weaker saline solution than its companion, as it is being freshened by overflow. While this renders it evident that it is of no economic importance, so far as its contained salts are concerned, it is of interest in reference to the proposed use of its water for irrigation, as it is not too highly saline for that purpose. The manner in which Malheur Lake is contributing its salts to Harney Lake, by the process of occasional overflow described above, is also of much interest to geologists, as it illustrates one method by which a lake may be freshened, while at the same time a companion lake is growing more and more saline.[a]

[a] The occasional outflow of water from Malheur Lake into Harney Lake, from which it escapes solely by evaporation, is a counterpart on a small scale of the process, now well advanced, by which the Caspian Sea is being relieved of a part of the saline matter it holds in solution. The Caspian is an inclosed lake, 181,000 square miles in area, the waters of which vary in chemical composition in different parts, but remote from the mouth of the Volga and other tributary streams contain 0.6494 per cent of total salts in solution. On the east side of the Caspian there is

The inner slopes of the valley in which Malheur and Harney lakes are situated are not scored with old beach lines or terraces, as is the case in so many of the similar valleys of the Great Basin. This is consistent with the low elevation of the old river channel leading eastward from the valley to the headwaters of Malheur River. As already stated, the present hydrographic basin of Malheur and Harney lakes was formerly a part of the Malheur River drainage system, and was cut off by a lava flow which entered the channel of the former and greater Malheur River. On account of the small precipitation and active evaporation in the region above the broad lava dam, the water in the basin thus cut off has never been able to rise sufficiently to cross the obstruction which retains it. The evidence thus furnished, tending to show that Malheur and Harney lakes are not remnants of a former large water body, is also in harmony with their chemical composition. Their present degree of salinity indicates but a comparatively short period of time since the dam which retains them was formed. The lava sheet referred to is, however, covered with a thin soil, and supports a rank growth of sagebrush, indicating that it is much older than the very recent lava flows about the Diamond, Bowden, and Jordan craters, to be described later.

SILVER LAKE.

In the valley of Silver Creek, about 11 miles northwest of Harney Lake, there is a small, shallow water body, termed Silver Lake, and sometimes referred to as Little Silver Lake to distinguish it from another and larger water body of the same name situated in Lake County, Oreg. The basin in which Silver Lake is situated is broad and flat, with indefinite boundaries, and during high-water stages becomes a wide expansion of the creek which flows through it. In summer the creek ceases to flow, and the lake is kept from evaporating to dryness by the contribution received from a hot spring on its southern border.

Several basins along the somewhat indefinite course of Silver Creek between Silver and Harney lakes become flooded in winter and completely desiccated in summer. When dry the floors of these shallow basins become absolutely barren mud plains or playas, some of which are 3 or more miles across. These yellowish floors of dried mud are sufficiently hard in summer to be crossed with a loaded wagon with-

a bay, about 100 miles in diameter, known as the Karaboghaz, or "bitter lake," which is connected with it by a strait 450 yards wide and 5 feet deep. The Karaboghaz has no inflowing streams and no outlet. The climate is arid, and on account of the loss from its surface by evaporation a current sets into it from the Caspian at a rate of from 1½ to 3 miles per hour. As computed by Van Baer, the amount of saline matter carried by this current is 350,000 tons per day. The Caspian is thus losing saline matter probably at a greater rate than it is being supplied, and the water of the Karaboghaz has been concentrated to such an extent that it is a saturated solution, and contains something like 24 per cent of saline matter, and from it common salt is being deposited. An instructive example is thus furnished of one method by which a saline lake may be relieved of its salts, and of one method also by which saline matter is concentrated and deposited in a solid form.

out leaving more than a faint trail. Their smooth surfaces are usually intersected in every direction by a network of shrinkage cracks, and about their borders there is in some instances a white incrustation of saline matter, which is left as the water which seeps down from the neighboring uplands is drawn to the surface by capillary attraction and evaporated. The characteristic vegetation about the borders of these and many other similar playas in the Great Basin region is the common greasewood. This shrub frequently attains a height of 4 to 6 feet, and, like most desert plants, grows in isolated clumps. These bushes encroach on the playas, and occupy an advanced picket line, where the conditions leading to survival or death are nearly evenly balanced. One result of this delicate adjustment is that during the periods when the playas are desiccated the wind blows away the dried sediment from between the clumps of bushes, and also drifts fine débris about them, so that rudely circular mounds are formed, which in many instances are 8 or 10 feet high and from 12 to 20 feet in diameter. (Pl. II, *B*.) The roots of the greasewood serve to retain the material forming the mounds, and the obstruction to the wind afforded by their branches also tends to preserve them. That the mounds are dependent on the greasewood for their preservation is well shown by the fact that when the bushes die the mounds soon disappear. In some instances a complete sequence can be observed, from large mounds crowned with a vigorous growth of greasewood through similar mounds on which the bushes are dead, and from those to others partially denuded by the wind, in which only the roots of the plants which formerly grew in them can be found, and from these again to low, indefinite hillocks on the desert, and even flat, circular areas which reveal the former presence of a mound solely by the fact that the surface is slightly softer and perhaps a little more moist than the broad, flat area about it. Although greasewood mounds of the nature just described are seemingly transient features of the borders of playas, they might, in certain situations, survive a change to more humid climatic conditions and the areas they occupy, becoming grass covered, be transformed into "mound prairies."

THE LAKES OF ALVORD VALLEY.

At the foot of the precipitous eastward-facing escarpment of Stein Mountain there is a well-defined valley, trending in general about northeast and southwest, which is fully 75 miles long, and about 8 miles wide in its widest part. This valley was evidently at some former time a part of a river system, but the topgraphic history of the extensive region of which it is a representative part remains to be deciphered.

In the widest part of Alvord Valley, and east of the highest portion of Stein Mountain, is situated Alvord Desert. This is a mud plain or playa throughout most of the year, but in the winter and

spring it becomes covered with a few inches or possibly 1 or 2 feet of water and transformed into a lake, which when fully expanded covers an area of between 50 and 60 square miles. The water supply for this winter lake is furnished principally by the small streams which descend the precipitous east face of Stein Mountain, but a small contribution is made by a hot spring on its southwest border. In summer the desiccated bed of the lake is a smooth, even, hard mud plain, crossed in every direction by a rather fine network of small shrinkage cracks. Scattered over the smooth and frequently glossy surface there are, at intervals usually of several rods, fragments of rock, some attaining a diameter of perhaps an inch. The manner in which these angular fragments reached their present resting place is obscure, but it is probable that they were transported and deposited by floating ice. Frequently on clear, hot summer days the delusive effects of the mirage relieve the desolate monotony of the desert and the surface is seemingly flooded with water. To the south of Alvord Desert and in the same valley or basin is another and smaller playa lake, known as Alvord Lake, which is supplied during the wet season by Trout Creek, and also receives the waters from a constantly flowing hot spring.

North of Alvord Desert the valley adjacent to the east base of Stein Mountain becomes narrow, its general width being about 2 miles, and the streams from the bordering mountains have deposited large alluvial cones, some of which extend entirely across the depression and meet the débris on its eastern side. In this manner the valley has been divided into a number of shallow basins, four of which hold small playa lakes, of which Juniper and Mann lakes are representative examples.

The basin in which Juniper Lake is situated was formerly more deeply flooded, as is shown by beach lines about its borders, and contained a lake about 7 miles long, 2 to 3 miles wide, and 100 feet deep. About the little valley in which Mann Lake occurs there are also faint beach lines which show that it formerly contained a lake approximately 150 feet deep and about 4 miles long and 2 miles wide. Several of the small basins between the sharp-crested ridges to the east of the two lakes just mentioned are occupied by mud flats in summer and by ephemeral lakelets in winter.[a]

FLUCTUATIONS OF LAKES AND EFFLORESCENCES.

The lakes of Harney and Alvord valleys, and other places described above, are similar in many ways to a large number of lakes scattered

[a] As the facts concerning a few of the inclosed lakes of Oregon here presented may perhaps lead the reader to wish to continue the study further, references are given to some of the more accessible reports, books, etc., bearing on the subject:

Russell, I. C., Geological history of Lake Lahontan: Mon. U. S. Geol. Survey, vol. 2, 1885.

Russell, I. C., Quaternary history of Mono Valley, California: Eighth Ann. Rept. U. S. Geol. Survey, 1889, pp. 261-394.

Gilbert, G. K., Lake Bonneville: Mon. U. S. Geol. Survey, vol. 1, 1890.

Russell, I. C., Lakes of North America, 1895.

throughout the Great Basin, but occurring principally in its northern half. The reason for the presence of more lakes in the valleys of the northern than in similar inclosed basins in the southern part of the Great Basin, is evidently due principally to a slightly greater mean annual precipitation and a slight decrease in evaporation as one journeys from the south toward the north in that region. The lakes of southeastern Oregon furnish an instructive contribution to the study of the delicate balancing of conditions referred to, and illustrate the manner in which mountains may become the controlling condition on which depend the existence of the lakes in neighboring valleys. For example, if mountains had not been upraised about the Harney Valley to act as condensers and give origin to streams, it is evident that the basins of that region would not have had lakes developed in their deeper portions.

Another feature in which the portion of Oregon here considered is representative of the Great Basin in general is the deep filling in the valleys. In a region which has no outflowing streams, all the material brought from the bordering or included uplands and mountains by the rain wash, rills, brooks, etc., is deposited in the valleys. For this reason the depressions normally become deeply filled with stream-deposited alluvium and with the sediments spread out in lakes. These two processes of deposition are frequently in operation at the same time, and it is extremely difficult in many instances to determine from a study of the accumulations whether they were made by flowing or by still water. In general the valleys throughout the Great Basin have been deeply filled with fine silt-like material having a light-yellow color, deposited in part by streams and in part in lakes. The valleys have thus been given nearly level floors in their central parts, and on their borders slope upward in gentle curves to meet the bordering hills and mountains. This is the case in the Harney and neighboring valleys, and the surface deposits of fine silt form rich soil, which needs only water to make it highly fruitful.

In a region devoid of outflowing streams all of the material brought to the valleys by streams in solution—their "invisible loads"—as well as all of the débris they carry in suspension—their visible loads—is left as the waters evaporate. Hence not only the lakes of such regions are characteristically alkaline, but the soils are apt to contain easily soluble salts. Within each inclosed basin there is an assorting and concentration of saline matter, and as frequently happens the lower lands are strongly alkaline. At times, as the waters evaporate, surface incrustations or efflorescences are formed, consisting principally of common salt, sodium sulphate, sodium carbonate, etc., but in rare instances they also contain boracic acid, and are valuable as sources of borax.

Several of the small playas in southeastern Oregon are covered in summer with white incrustations of the nature just described. A

sample of one of these from near Dog Mountain, about 6 miles west of Narrows, gave the following result on chemical analysis:

Analysis of efflorescence from near Narrows, Oreg.

[Analyst, George Steiger.]

Insoluble in hot water	1.25
Sodium oxide, Na_2O	47.49
Water, H_2O (of crystallization)	10.08
Sulphuric anhydride, SO_3	11.76
Chlorine, Cl	2.90
Carbon dioxide, CO_2 (carbonic acid gas)	26.33
Boracic acid, B_2O_3	.28
Total	100.09

PROXIMATE COMPOSITION.

Insoluble in hot water	1.25
Sodium carbonate, Na_2CO_3	55.91
Sodium bicarbonate, $NaHCO_3$	5.98
Sodium sulphate, Na_2SO_4	20.88
Sodium chloride, NaCl	6.17
Sodium biborate, $Na_2B_4O_7$ (borax)	.46
Water, H_2O (of crystallization)	9.44
Total	100.09

Judging from the above analysis, the efflorescence from which the sample examined was obtained, if in sufficient quantity and commercially accessible, would be of value for the sodium carbonate and sodium bicarbonate it contains, but not for its borax.

Every surface incrustation of the nature described above, when of sufficient quantity to be of commercial value in case it contains sodium bicarbonate, borax, etc., should be carefully sampled and a representative portion analyzed. In every playa also auger holes should be bored for the purpose of discovering if deposits of valuable salts exist below the surface. The clays and silts in a playa should also be tested, as they may have absorbed sufficient borax or other salts to make them of commercial value.

GEOLOGY.

RECENT VOLCANOES.

Some account of the recent but now extinct volcanoes of southern Idaho was presented in my report on field work done in 1901,[a] and additional data in this connection were obtained during the reconnaissance which furnishes the basis of the present report. In 1902 the Cinder Buttes, the most instructive group of recently extinct volcanoes thus far discovered in Idaho, were revisited, and three separate centers of recent volcanic activity in southern Oregon, not previously

[a] Bull. U. S. Geol. Survey No. 199.

known to geologists, also examined. The facts observed in connection with these four modern and still well-preserved volcanoes or groups of volcanoes, when taken in connection with the studies already made of many other similar examples in the same region, not only contribute to a better understanding of volcanic phenomena in general, but aid in an important way in the interpretation of the records of the far more extensive lava flows of greater age in the same region.

The more instructive features of the recent volcanoes of Idaho, described in the report referred to above, may be briefly summarized as follows: The lava extruded is in all instances a dark basic rock, and may all be classed as basalt. In physical characteristics it ranges from compact, columnar rock to highly scoriaceous and even pumice-like material. The lava was extruded from the volcanic conduits in two ways: part, and by far the larger part, flowed out in a highly liquid condition and spread widely over the surface before cooling and hardening, and part was blown into the air as angular fragments or as clots, bombs, etc., which fell on the adjacent surface and built more or less conspicuous elevations. The material extruded in each of these ways presents many variations in its physical condition, dependent on secondary influences.

Of the lava which flowed out in streams two principal varieties may be recognized; one division includes the rocks formed by the cooling of the molten material on land, which, although at times highly scoriaceous, especially at the surface of the sheets, is in general a dense, compact rock, and on account of the formation of joints as it cooled is frequently columnar; the other division contains the lavas which entered surface water bodies and became expanded and "shredded," or shattered by the resulting steam explosions. The lava which was blown into the air presents an interesting series of forms, ranging from angular fragments produced by the shattering of the material after it had become cool and rigid, through clots, bombs, lava cakes, etc., formed of more and more plastic lava, to splashes of the magma which were still highly liquid when they fell.

From the two principal variations in the manner in which the volcanoes discharged their lava, two types of elevations about the mouths of their conduits resulted. The explosive eruptions led to the building of lapilli and cinder cones, a considerable range in the forms produced resulting from the degree of rigidity or plasticity of the projected fragments and the extent to which they cooled before striking the surface. These elevations are usually steep sided and contain depressions or craters in their summits, and as a class may be termed cinder cones. The lava overflows occurred for the most part quietly, without explosions, although in general, as it is believed, following explosive eruptions which opened the volcanic conduits for the free discharge of the molten rock which rose later and was poured out in such volume that the extruded material cooled in a mound above the

orifice from which it came and flowed outward in all directions, forming what it is convenient to term lava cones. The cinder cones are high in reference to their diameters, with steep and normally concave slopes, while the lava cones are usually low, with gentle and at times convex sides and immensely expanded bases.

One of the most notable facts connected with the volcanoes in question is the vastness of the lava fields spread out about them in comparison with the size of the cinder or lava cones found at the summits of the conduits from which the material came.

On the surfaces of the lava flows there are two principal features, which are dependent on the ratio between the motion of the lava and the degree of rigidity of the crust formed on its surface as cooling progressed. When the cooling and stiffening of the surface occurred without marked disturbance from the flow of the still liquid material beneath, smooth, swelling, convex surfaces resulted, which at times were wrinkled and even forced upward into hollow folds. These folds show the characteristics of pahoehoe, as such surfaces are termed in the Hawaiian Islands. (Pl. XII, *A*.) When, however, the underflow beneath a brittle crust caused it to become fractured, and the fragments thus produced were tossed about in much the same manner that the cakes of ice in an ice jam are crushed together and piled up, a rugged surface, simulating what is termed *aa* in the Hawaiian Islands, resulted. (Pl. XII, *B*.)

The numerous instructive features just referred to, which were described and discussed in some detail in the report on the observations made in 1901,[a] were found in the crater and lava flows of southeastern Oregon examined in 1902, and still other phenomena belonging to the same general category were observed. The reexamination of the Cinder Buttes enabled me to verify and extend the results previously recorded.

CINDER BUTTES.

The Cinder Buttes are situated on the west side of the Snake River Plains, about 70 miles west of Blackfoot, Idaho. They are not conspicuous on account of size, as the highest crater in the group rises but 600 feet above the adjacent plain, but are remarkable for the vast amount of lava that flowed from them and for the many instructive details they present in reference to the behavior of volcanoes which erupt basic and easily fusible lava.

The additional facts concerning this most interesting group of craters and lava flows, at least in a measure supplementing the account of them already published,[a] relate principally to the floating away of large fragments of a ruptured tuff cone on the surface of the outflowing lava stream, a greater variety in the volcanic bombs occurring about the crater than was previously known, and the occurrence of

[a] Bull. U. S. Geol. Survey No. 199.

A.

B.

CRAGS OF TUFF ON LAVA FLOW, CINDER BUTTES, IDAHO.

distinct beds of compact lava in the walls of cinder cones, due to the running together and hardening into a single mass of many splashes of liquid lava, etc.

Breached cinder cones and crags of tuff floated on lava streams.—There are several well-defined craters built of lapilli and scoria among the Cinder Buttes, which were breached by the lava that escaped from them, and in one instance of this nature large masses of the parent crater were floated away on the surface of the lava stream which escaped through an opening in its wall. The floated masses range in general from 20 to 50 feet in diameter and from 40 to 50 feet or more on a side. They occur in a well-defined train, extending down the lava stream which escaped from a breach in the parent crater for a distance of about 2 miles. The masses are always angular and are bounded by rough surfaces that have resulted from fracture. They consist of reddish tuff, formed by the partial consolidation of lapilli, or of adhering clots of lava that were plastic when they were brought together. In color and composition they correspond with the portion of the cinder and lapilli cone still remaining intact, and differ from all other rock in their vicinity. They are in striking contrast with the black, generally smooth but in places wrinkled or fractured lava surface on which they occur. About the base of nearly every one of the crags the surface of the sustaining lava is depressed so as to form a moat-like trough which completely encircles it. Some of the features just described, including the depressions encircling the bases of the crags, may be recognized in the accompanying photographs. (Pl. III.)

It is of interest to note that the surface of several of the lava streams about the Cinder Buttes, for a distance of a mile or two from their sources, has subsided since it hardened, owing to an outflow of the still liquid lava from beneath a rigid crust. The amount of this subsidence is in several instances from 50 to 70 feet. As a result of such subsidence in the central part of a lava stream its marginal portions are sometimes left stranded, and a precipitous broken escarpment, facing the subsided area, borders the portion of the stream from which the lava outflowed. On the border of a lava stream which has been lowered at times large blocks of the stranded crust slope downward toward the subsided area.

In the case of the Northwest lava flow, i. e., the one on which the crags of tuff, etc., described above, occur, there has been a subsidence of the surface of the flow throughout the first mile or more of its course, and a lowering of the crust formed on its central part of 50 to 70 feet. A portion of the flow, a square mile or more in area on the west side of the stream, was left stranded by this subsidence at a higher level than the surface of the lava, which continued to flow to the north.

From the facts briefly described above it seems evident that the crags of tuff, etc., on the surface of the Northwest lava streams are

fragments of the breached crater from which the lava came, and that they were floated on the surface of the plastic lava. The floated fragments are composed of rock which, on account of its porous and usually scoriaceous condition, is lighter than the usually compact lava on which they occur, but they depressed the viscous surface on which they rested in the same manner that a brick might depress the surface of pitch. The floated fragments were not carried to the end of the lava flow, for the reason that a crust was formed on the stream of molten rock from beneath which the still liquid material escaped. Owing to the outflow beneath, the crust remained stationary and with its freight of tuff was gradually lowered to the position it now occupies. That the crags to which attention has been directed are not islands in the lava stream is clearly shown by comparing them with well-characterized occurrences of that nature, one of which is shown on Pl. IV, *A*. The stranded blocks of lava about an island in a lava stream which has subsided are inclined away from it, as may be seen in an example of this nature shown in the photograph just referred to. In such instances the result is much the same as may be observed on the borders of a river which has subsided after a sheet of ice had formed on its surface; in instances of this nature, as is well known, cakes of ice left stranded on the banks of the stream are inclined downward toward its center. About the islands in a lava stream which has been lowered by the outflow of the liquid rock from beneath a solid crust, the portions of the crust left stranded slope away from the central part of the island and nothing resembling the moat-like depression observed about the floated crags described above is even suggested.

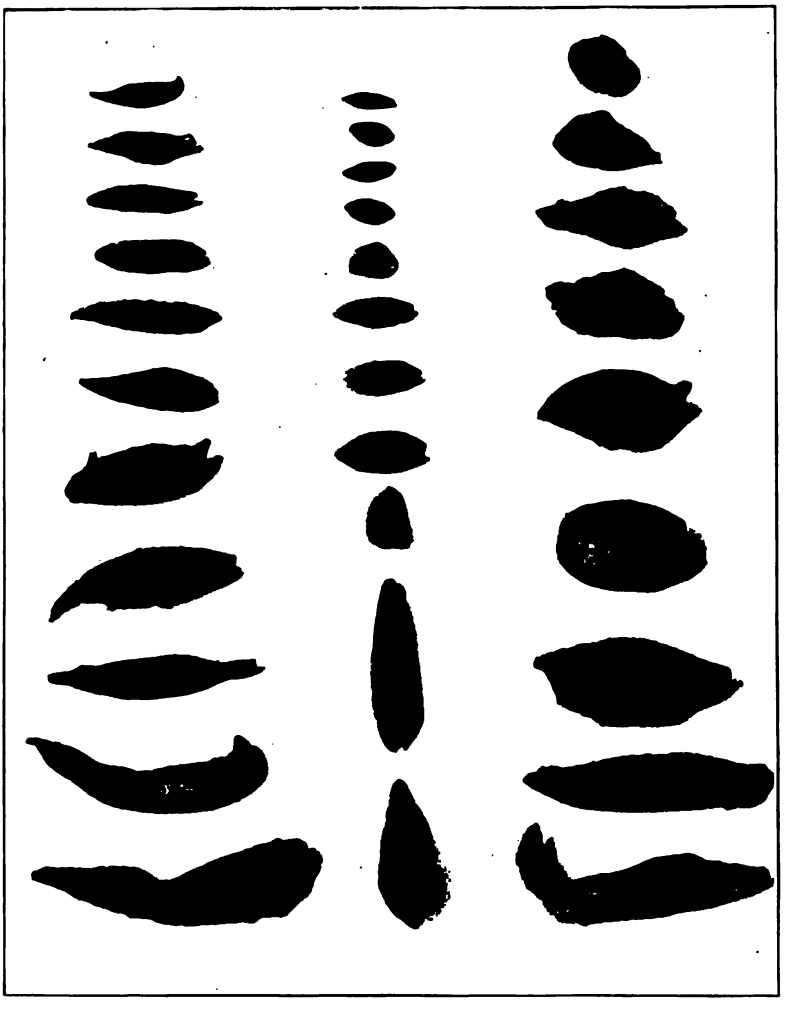
In some instances observed about the Cinder Buttes, the subsidence of the central part of a lava appear to have been so gentle that the surface sheet of stiffened but still somewhat plastic material was not seriously broken, and still remains in the condition of pahoehoe. At other times a more rapid lowering of the surface, or the presence of a rigid and brittle crust, caused a large amount of fracturing and the heaping up of the pieces produced so as to make a characteristic *aa* surface. About the bases of the floated crags on the Northwest lava flow, described above, typical examples of each of these classes of lava surfaces are to be found. In some instances the crags rise from smooth, swelling, and frequently corrugated pahoehoe surfaces, and at other places are surrounded by the chaos that is characteristic of *aa* surfaces.

Volcanic bombs.—The volcanic bombs strewn about the Cinder Buttes are so abundant that in several instances they form a large part of the material of which the craters are composed and present several well-characterized varieties.

The term "volcanic bomb" is usually employed to designate the class of projectiles blown out of volcanoes, which, on account of their

A. ISLAND OF LAPILLI IN LAVA STREAM, CINDER BUTTES, IDAHO.

B. SCORIA AND BOMB CONES, "THE ICE WELLS," CINDER BUTTES, IDAHO.



VOLCANIC BOMBS, CINDER BUTTES, IDAHO.

Four-tenths natural size.

revolving about an axis during their flight and while still plastic, assumed more or less regular spherical or ellipsoidal shapes. Typical examples of such bombs, ranging in form from nearly perfect spheres to elongated oval bodies with projections or "ears" at the ends of the longer axis, were obtained in abundance. The central body as well as the projections in those examples are marked by spiral lines and ridges, produced by the rotation of the mass while yet hot and viscous or plastic. Illustrations of such forms which preserve unmistakable evidence of having rotated while yet plastic are presented on Pls. V–VI. The bombs which most nearly approached the typical shapes just referred to range in size from less than an inch in length to masses that are 9 feet long and 12 feet in circumference in the center. In addition to the bombs with characteristic spherical or ovoid shapes, many other forms, some of them conspicuously irregular, were noted.

In some instances, as illustrated on Pl. VI, a mass of plastic lava, after being fired into the air and acquiring the common "foot-ball" shape, seems to have fallen straight downward, and the projecting ends or ears, being still plastic, were bent inward and perhaps flattened on the central portion of the mass. A great variety of bombs of this description, with recurved and infolded ears, was observed. Examples are also common of masses of lava which were projected into the air, and on falling acquired a pear-shaped or tear-drop form. These bodies, which seem to have fallen straight downward, as is indicated by their shapes, are of all sizes up to 2 feet or more in diameter. In many instances the tapering end is curved, or even folded down onto the body of the bomb, so as to produce shapes curiously like certain varieties of squash with curved necks These pear-shaped and squash-shaped bombs were in many observed instances evidently still plastic when they struck the ground, as is shown not only by the fragments of lapilli, etc., adhering to their lower surfaces, and partially embedded in their outer crusts, but by a bulging at the base or flattening due to a change of shape on striking.

In addition to the bombs with more or less symmetrical forms, due to masses of plastic lava cooling and stiffening while rotating in the air or falling from aloft, there are many irregularly shaped bodies which originated in a similar manner. These are frequently greatly elongated, loosely twisted shreds, perhaps several feet long and only a few inches in transverse diameter in the thickest part. One of the most bizarre of these irregular forms is represented on Pl. VIII. This ram's horn-like body of dense light-colored lava measures 13 feet in length and 8 inches in diameter in the thickest portion. It lies on the west side of the highest of the Cinder Buttes, about one-third of the way from its base to the top, and was hurled through the air to a distance of about one-half mile. On striking, it was still sufficiently plastic to become indented by the stones on which it fell, some of

which still adhere to its lower surface. On account of its plastic consistency it did not break when it fell, but has since been fractured, probably on account of changes of temperature.

Many projectiles, either complete or more or less shattered, of the same general character as the one shown on Pl. VIII, occur about the Cinder Buttes, and in most if not all instances they are composed of dense, compact, light-colored rock, which on freshly fractured surfaces looks not unlike hard-burned stoneware and resembles the material forming the immediate borders of basaltic dikes or, the whole of very thin dikes of similar character. It is evident that the lava forming the irregular shred-like bombs cooled quickly from a liquid or highly plastic condition, and that the steam and gasses contained in the original magma escaped, for the most part, without leaving vesicles.

When the bombs are broken so as to expose their interiors they present at least three well-defined variations in structure. Certain ones, including the elongate, twisted forms described above, are compact throughout or exhibit only irregular and, frequently, much extended cavities, such as steam or gases leave in cooling lava, and are either light, and in fact almost white, or glossy black in color. In sections at right angles to the longer axis something of a spiral arrangement of the steam cavities, cracks, etc., is apparent, and on their exterior there is more or less evidence of the influence of rotation while the mass was still plastic. The bombs having these characteristics seem to have been formed of highly plastic or nearly liquid lava, from which the contained steam and gases escaped freely.

Bombs of a second variety, characterized by their rudely spherical shapes, rough exteriors, and highly vesicular and frequently nearly hollow interiors, but without surface crusts, spiral lines or ridges, or projecting ears, occur in abundance, especially in the walls of parasitic cones or what may perhaps be termed driblet cones of large size. These rough spheres range in diameter from a few inches up to 2 feet or more, and the walls of the large cavities within frequently present the appearance of "pulled dough," as if marked expansion of the steam cavities had occurred while the material was viscous. (Pl. VII.) The bombs of this variety are sometimes flattened and bear on their under surfaces impressions of the material on which they fell. At times they adhere one to another, and in some instances were sufficiently plastic to flow after coming to rest. The occurrence of these bombs in chimney-like piles, about openings in lava streams, and in the walls of the so-called ovens to be described later, indicates that they were tossed out of openings in the crusts of lava streams, but did not make any considerable journey in the air. They form a connection between projected clots of vesicular lava, such as are commonly termed "cinders," and true bombs, which were thrown to a considerable height and cooled while rotating.

VOLCANIC BOMB, CINDER BUTTES, IDAHO.

Four-tenths natural size.

VOLCANIC BOMBS, CINDER BUTTES, IDAHO.

Three-tenths natural size.

VOLCANIC BOMB, CINDER BUTTES, IDAHO.

Length, 13 feet; greatest diameter, 8 inches.

The third common type of bombs includes those which are cellular within—the vesicles diminishing gradually in size from center to circumference—and inclosed in a thin rind or crust. In some instances there is a thin layer of cellular lava on the outside of the hard rind, but more frequently the surface is smooth, glossy black, and in many examples broken by shrinkage cracks which have been widened by the expansion of the material within after a thin surface crust had formed. (Pl. X, *A*.)

The interior structure of these bombs closely resembles that of certain bombs found on Ascension Island and described by Charles Darwin. In order to show this resemblance more definitely, a figure of a partial section of one of the bombs referred to, published by Darwin,[a] is reproduced on Pl. IX by the side of a similar specimen from the Cinder Buttes. In each case there is a conspicuous and gradual increase in the size of the vesicles in the central scoriaceous mass, from the inner side of the inclosing rind to the center. The explanation of this peculiar internal structure advanced by Darwin is as follows:

> This structure is very simply explained, if we suppose a mass of viscid, scoriaceous matter to be projected with a rapid, rotatory motion through the air, for while the external crust, from cooling, became solidified (in the state we now see it), the centrifugal force, by relieving the pressure in the interior parts of the bomb, would allow the heated vapors to expand their cells; but these being driven by the same force against the already hardened crust would become, the nearer they were to this part, smaller and smaller or less expanded until they became packed into a solid, concentric shell. As we know that chips from a grindstone can be flirted off when made to revolve with sufficient velocity, we need not doubt that the centrifugal force would have power to modify the structure of a softened bomb in the manner here supposed. Geologists have remarked that the external form of a bomb at once bespeaks the history of its aerial course, and we now see that the internal structure can speak with almost equal plainness of its rotatory movement.

As stated in my report on a reconnaissance in Idaho in 1901,[b] the observations then made concerning the cellular bombs strewn about the Cinder Buttes are not in harmony with the explanation quoted above. Later studies serve to strengthen this conclusion and to lend additional support to the hypothesis advanced in the bulletin referred to. In brief the explanation of the cellular condition of the bombs in question, and the increase in the size of the vesicles they contain from beneath the crust to the center, which apparently best satisfies the observed facts, is that masses of steam-charged lava, tossed into the air from pools of liquid rock in craters, cooled quickly at the surface and formed a dense crust, which prevented further escape of steam from within, and as the lava continued to cool, the change gradually progressing from the circumference inward, there was an

[a] Darwin, Charles, Geological observations on volcanic islands visited during the voyage of H. M. S. *Beagle*, London, 1844, p. 36.

[b] Bull. U. S. Geol. Survey No. 199.

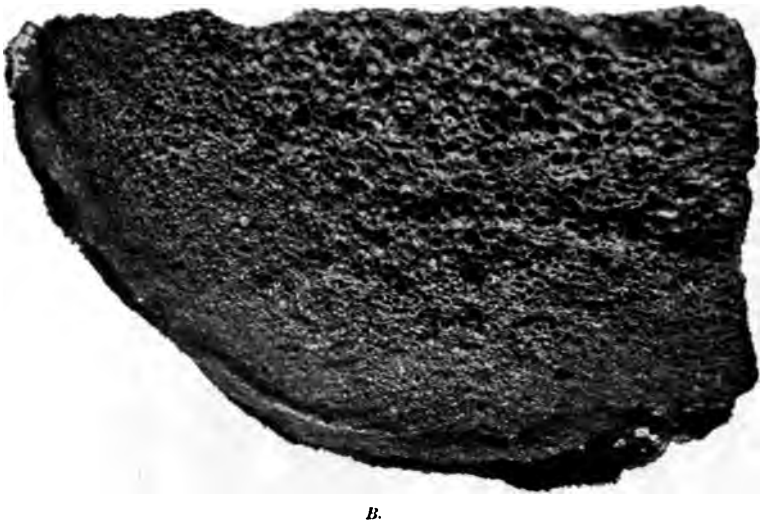
extrusion from the cooling lava of steam or gases previously held in solution in the molten rock. The regeneration of steam or gases in this manner would tend to expand a bomb, thus leading to a cracking of the first formed crust and a widening of the cracks, as is illustrated on Pl. X, *A*. The change referred to would also favor the formation of larger and larger vesicles within a bomb as the cooling and stiffening of the material composing it progressed. In addition to the facts referred to tending to support the hypothesis here restated, it may be noted that the bombs seen about the Cinder Buttes which show the internal structure, neither in their forms nor in their surface markings exhibit evidences of rapid rotation, and moreover occur on the crests and inner slopes of craters or in situations that do not indicate a long aerial flight. The impression that one gains from seeing large numbers of these bombs in the position in which they fell is that they are formed of masses of plastic lava which were tossed out of craters with only sufficient rotary motion to give a spherical form, but were not fired high in the air and did not acquire the spindle shape with twisted projections at either end, so characteristic of bombs that rotate rapidly while cooling.

Bombs of the various external shapes and with the wide range in interior structure described above occur in great numbers about the Cinder Buttes, and in fact furnish a very considerable portion of the fragmental material of which they are composed. Mingled with the bombs in the walls of many of the craters, as previously described,[a] are great quantities of thin, nearly flat, cake-like masses of lava, which were formed by the cooling and hardening of small bodies or splashes of lava that had been projected into the air and were still liquid when they fell. These flat cakes furnish illustrations of one extreme of the many variations presented by the material thrown out by volcanoes during explosive eruptions; a series which includes scoria, clots, several varieties of volcanic bombs, and angular fragments, such as lava blocks, lapilli, volcanic dust, etc. This wide range in the products of volcanic explosions in reality presents an orderly sequence, dependent on the degree of fluidity, plasticity, or rigidity of the material at the time it was blown into the air.

If the material forming the summit portion of the column of lava within the conduit of a volcano becomes rigid before steam explosions beneath cause it to be fractured and the fragments blown into the air, angular blocks of lava, lapilli, dust, etc., are produced. If the material is plastic or viscous, clots may be blown out, and cool as scoriaceous masses, or so-called cinders, which have rough, irregular, but not fractured surfaces. If such clots are projected high in the air and cool while rotating, bombs result. Should the lava be still more thoroughly fused at the time it is projected into the air, it may still be liquid on striking, and form lava cakes, or even spread over the

[a] Bull. U. S. Geol. Survey No. 199.

A.



B.

SECTIONS OF VESICULAR VOLCANIC BOMBS.

Fig. *B* is one-third natural size.

A. CRACKED SURFACE OF VOLCANIC BOMB, CINDER BUTTES, IDAHO.

Four-tenths natural size.

B. FRAGMENT FROM A CINDER CONE, SHOWING DENSE PORTION DUE TO HARDENING OF SPLASHES OF LIQUID LAVA, CINDER BUTTES, IDAHO.

Four-tenths natural size.

surface and, additional material of the same character being supplied, form tile-like sheets. This entire sequence is admirably illustrated by the projectiles which accumulated to form the Cinder Buttes.

The occasional presence of balls of dense lava on the surfaces of lava flows, described by J. D. Dana in the case of certain lava streams in the Hawaiian Islands, and observed by me in Idaho,[a] as well as the presence of analagous spherical masses of lava in the crater walls of certain of the Cinder Buttes, suggest, as a tentative hypothesis, that during the boiling of lava in a crater, masses of fused rock may become cooled, and, owing to rotation produced by the movement of the molten or plastic material about them, acquire a spherical form before being blown out or carried away by outflowing lava. The compact, rough-surfaced, spherical balls sometimes found about volcanoes appear to have originated in some such manner, and not from the rotation of plastic material projected into the air.

The sequence of events in the history of the Cinder Buttes, as recorded by the accumulations of projectiles still remaining and by the extensive lava flows which were discharged from the same volcanic vents, is briefly as follows: The eruptions in a large number of instances began, so far as can be judged from the evidence now available, with explosions which caused considerable quantities of cool and rigid lava in the form of lapilli, dust, etc., to be projected into the air. Later came similar violent discharges of plastic lava which formed scoria and volcanic bombs, and later still, liquid lava was ejected. This fell before cooling, and spreading over the surface where it struck formed lava cakes. Following these explosive discharges, or accompanying the later ones, great volumes of highly liquid lava were poured out. This lava was extruded quietly and flowed over the surface of the surrounding plain so as to form sheets many square miles in area. The close of the eruptions, in several instances at least, was not characterized by a return of the conditions which produce explosions, but the outflow of liquid lava decreased gradually and finally ceased, the craters being left with nearly level floors of highly vesicular rock having the surface characteristic of pahoehoe.

Lapilli cones, cinder cones, etc.—The term cinder cone is commonly used to designate the piles of projectiles which have accumulated about volcanic vents, irrespective of their precise character. While the cones and craters referred to are in general composed of irregular scoriaceous masses of lava, usually referred to as "cinders," it will be seen from the brief description given above of the wide range in the nature of the projectiles of which they are composed that several varieties of "cinder cones" should be recognized.

When angular fragments of hard lava, such as blocks of rock, lapilli, dust, etc., are blown out of volcanic vents, they usually fall about the opening from which they come and accumulate in a conical pile

[a] Bull. U. S. Geol. Survey No. 199, p. 114.

with a depression or crater at the summit. The outer slopes of these cones frequently form angles of 30° to 35° with a horizontal plain, the angle being essentially the angle of repose of the fragments of which they are built, but their profiles are concave instead of straight lines. The reason for the downward curves presented by the sides of such cones is not definitely understood, but seems to depend on the fact that the structures are built of fragments of different sizes and shapes. Vertical sections through such piles commonly show, as is well known, two series of beds, one series dipping away from the crater in the summit, and forming the outer slopes of the cones, and the other series dipping from the rim of the crater toward its bottom. The junction between these two series of opposite-dipping beds in the rim of a crater is not a sharp angle, as sometimes represented, but a curve, convex upward. The cones referred to are symmetrical when built of fragments projected vertically, unless the influence of the wind in carrying the material in one direction more than another made itself felt. Cones or craters built of angular fragments with surfaces produced by fractures are sufficiently distinct from the similar structures built of other kinds of projectiles to be specially designated, and may with propriety be termed *lapilli craters*, or lapilli cones in case a depression in the summit of the pile is absent.

When the material projected into the air from a volcanic vent is plastic, and falls in irregular clots and rough scoriaceous masses, it frequently forms steep-sided piles with chimney-like openings within. Owing to the frequently large size of the masses which fall, their rough surfaces, and also to the fact that they are in many instances still plastic when they come to rest, the slopes of the structures produced, both on the outside and within, are commonly steep, and in some instances are nearly vertical, but the outer slopes of these hollow piles are normally less steep than the walls of the openings within. Piles of congealed clots of this nature present several instructive variations. At times they are steep-sided chimney-like forms, such as are illustrated on Pl. III. In other instances their encircling walls are contracted at the top so as to leave only small openings, and in extreme examples of this nature a complete roof is formed by the adhering of the clots blown out, and a beehive or oven-like structure results, such as is shown on Pl. XI. The chimney-like elevations produced in the manner just referred to have been designated driblet cones by J. D. Dana, but for the entire series of cones, craters, etc., built of scoriaceous or cinder-like clots of lava the term cinder crater or cinder cone seems appropriate.

For the sake of avoiding a lengthy discussion of the classification of elevations produced by the accumulation of volcanic projectiles about the vents from which they were blown out, I may briefly state that in certain instances well-characterized volcanic bombs form the *greater portion* of an elevation with a crater in its top, and in some

instances similar elevations are composed principally of lava cakes formed, as already explained, by the cooling of splashes of liquid lava after coming to rest. Examples of cones or craters formed exclusively or in large part by the two methods just cited, however, are so rare that special names for them do not seem to be necessary.

It frequently happens that a volcanic hill or mountain is composed of projectiles of all the classes considered above, as, for example, when large angular blocks of lava are ejected, together with lapilli and dust, and at some time in the life of the volcano plastic or liquid lava is blown into the air and forms scoria, bombs, lava cakes, etc. Such composite cones or craters built of the products of explosive eruptions are illustrated by several characteristic examples among the Cinder Buttes.

There is one feature of lapilli and scoria cones which does not seem heretofore to have attracted attention. Interbedded with the fragmental material in the walls of such craters there are sometimes irregular sheets of compact and usually reddish lava, ranging in thickness from a few inches or less to many feet, and presenting all variations in extent from a few square inches to several hundred square yards, and resembling true lava flows. These compact layers occur both in the outer and inner slopes of a crater, and at times a single bed in one part belongs with the steeply sloping layers of the inner cone, and changing its dip in the part beneath the crater's rim, passes into the outward-dipping series of beds. As may be seen at the Cinder Buttes, such beds of compact lava sometimes contain scoriaceous masses, and on their edges become thin and terminate irregularly in accumulations of lapilli or scoria. Some of these features may be recognized in the small sample from the wall of a cinder cone, shown in Pl. X, *B*.

The range in size of the compact beds just described, the presence in them of scoriaceous masses, and the manner in which they terminate, etc., show that they are due to an accumulation of liquid or highly plastic splashes and clots of lava, which united one with another as they fell. In harmony with this explanation is the fact that in many instances a sheet of lava of the nature under consideration is completely inclosed in lapilli or scoria. In sections of lapilli and scoria cones to be seen among the Cinder Buttes numerous examples of interbedded sheets of compact lava may be seen which are due to the running together of liquid or highly plastic splashes and clots in the manner just explained, and similar occurrences were seen elsewhere, particularly at the Jordan Craters described below.

The notes presented above are intended as a supplement to the more general account of the Cinder Buttes contained in Bulletin No. 199 of the United States Geological Survey, and I trust will be followed by a detailed survey of that unique region. In the publication just referred to, several isolated craters and groups of craters situated in southern Idaho are described, and the list of these recent volcanoes is here extended by an account of three similar centers of eruption in southeastern Oregon.

JORDAN CRATERS.

In the east-central part of Malheur County, Oreg., and from 18 to 20 miles west of the Idaho-Oregon boundary, there are four recently extinct volcanoes, which are here termed, collectively, the Jordan Craters. They are situated to the north of Jordan Creek, and to the west of its tributary known as Cow Creek. The four craters referred to are nearly on a line bearing a little west of north and are approximately 3 to 5 miles apart, although the distance of the one at the north from its next neighbor is somewhat greater than the spaces between the others in the series. While but four recent craters are here referred to, there are certain rounded hills to the west of the south end of the series which are probably of volcanic origin, and perhaps represent ancient craters, but these have not yet been examined.

Three of the four craters referred to—that is, all but the most northerly in the series—are situated in a valley, and the lava which flowed from them spread in all directions and built up lava cones with broad bases and low surface slopes. Each crater rises about 500 feet above the plain, but by far the greater part of this elevation is gained in the broad, low lava slopes surrounding the small buttes which mark the centers of eruption. The central elevations are in general about 150 feet high, and are composed of lava which occurs mostly in thin sheets. There is an absence of scoria in detached clots and of lapilli or other ejected material, such as is blown into the air during explosive eruptions. In short, they are elevations formed by the cooling and hardening of lava which overflowed from the summits of volcanic conduits in all directions, so as to form low cones with immensely expanded bases. When seen in profile, especially at sunrise or sunset, they are at once recognized as typical examples of what I have ventured to term lava cones in distinction from elevations built by the accumulation of projectiles.

The central and summit portion of each of the Jordan Craters is usually circular, with steep outer slopes, and in one instance contains a crater-like depression. This cavity in the summit of the cone, as in the case of many similar lava cones in Idaho and Oregon, is due to the falling in of a dome-like structure composed of thin lava sheets, the subsidence being caused by the escape of still liquid lava laterally from beneath a rigid crust.

It is convenient to designate the Jordan Craters by numbers, beginning at the south end of the series and proceeding northward. A brief examination serves to show that No. 1 is the oldest in the series; next in age is No. 3, then No. 2, and last and youngest of all, No. 4. Their relative ages are shown by the degree to which their surfaces are weathered and the extent to which they are covered with soil and vegetation. The slopes of the oldest crater are smooth, with but few

rocky crags visible, and are covered with soil mostly of eolian origin, in which a strong growth of sagebrush, etc., is conspicuous. Crater No. 3 is less completely concealed beneath accumulations of atmospheric dust than No. 1, and is less densely overgrown with sagebrush, while No. 2 presents a rough surface of hard black lava, on which pressure ridges are conspicuous, although notable quantities of atmospheric dust have accumulated in the depressions, and bushes and bunch grass grow in cracks and crevices on seemingly bare cindery crags and ridges.

While Craters Nos. 1, 2, and 3 are instructive on account of the many square miles of lava poured out from them and the various stages reached in its change to smooth pasture land, the chief interest of the general locality centers about Crater No. 4, at the north end, the youngest of the series.

Crater No. 4.—This very modern crater, unlike its companions, came into existence on a somewhat steep-sloping hillside, which was trenched by erosion channels previous to the volcanic outburst, and the great flood of extruded lava flowed away in one principal direction. Owing to the freedom afforded for the escape of the lava down the slope below the orifice from which it came, a large portion of the cinder and lapilli crater, built during an early stage in the history of the volcano, has been spared, and furnishes important evidence as to the general sequence of events, which, as it now appears, normally accompany the building of lava cones.

Crater No. 4, as it exists to-day, is in part a cinder and lapilli cone, and in part a lava cone, and extending over an area of about 50 square miles on its southeastern side is a black lava field entirely bare of vegetation (Pl. XII, *A*). Although differing conspicuously in its details from the associated craters in the same series, the one here considered was evidently built in the same manner as its companions, but owing to its being located on a sloping surface, the products of the earlier stages of the eruption which built it were not buried by the great effusion of highly liquid lava poured out later, as was the case in numerous observed instances, where similar eruptions have occurred on a plain.

Throughout about one-half of the periphery of the cinder and lapilli cone forming Crater No. 4, the older rocks, consisting mainly of Tertiary rhyolite, are without a covering other than a thin layer of soil, to within a distance of 800 or 1,000 feet of its base. This fact suggests that some evidence may perhaps be obtainable as to the nature of the break or opening through which the eruption that built the crater reached the surface. The testimony in this connection, however, is meager. On the hillside, where the crater is situated, and extending in an essentially straight line from it, both to the north and south, there is a faint escarpment averaging perhaps 15 feet in height, and facing east. This escarpment has the general appearance of a fault

scarp, but is by no means certainly of that nature. The only unquestionable evidence of a break in the rocks on which the crater stands is furnished by a row of about 12 driblet cones, situated in a line extending west from the principal center of eruption and up the slope of the hill at right angles to the faint escarpment referred to above. The portion of the break on which the driblet cones are located, situated at a distance of about 1,000 feet from the center of the main crater, shows no evidence of a differential movement of its walls. There is then but slight evidence of a shattering or faulting of the country rock preceding or following the birth of the volcano.

The portion of the original pile of cinder and lapilli remaining at Crater No. 4 is highest on the south side of the crater, where it rises about 100 feet above its outer base and somewhat more above the irregular pit it partially inclosed. The cone has lost much of its symmetry, owing to the falling of its inner surface, and on the south side of the crater presents a fairly good section of outward-dipping layers of lapilli and of compact reddish lava. The compact layers referred to are among the more interesting features of the section, and while having the appearance of lava flows which descended the outer slope of the lapilli and scoria cones when it was but partially completed, are in reality due to the flowing together and cooling in one mass of many splashes of liquid lava. This mode of origin of the dense compact layer is shown by it containing angular fragments of lapilli and by small, isolated, lenticular masses of the same nature completely embedded in lapilli, with which it forms a complete gradation. More than this, the surrounding surface of rhyolite, adjacent to the base of the cinder and lapilli cone, where not concealed beneath lava flows, and to a distance of about 800 feet, is thickly strewn with reddish clots of lava, which were liquid when they fell and in general ran together, so as to form a tide-like sheathing to the surface. This material spattered out of the crater and falling well beyond, its base is of the same character as the layer of dense lava built into its wall and covered by subsequent showers of lapilli. The preservation of the rough, angular pavement, composed of congealed splashes of lava about the crater, which fell in a liquid condition, thus serves to explain the history of at least certain compact layers in the walls of the cinder cone, the most noticeable of which has a thickness of between 10 and 20 feet. Similar compact, usually reddish, layers of lava in cinder cones have been observed at the Cinder Buttes and elsewhere, as already explained, and are evidently a common feature of the walls of cinder and lapilli craters built by volcanoes which discharged highly liquid lava.

After a small cinder and lapilli crater had been built by the volcano under discussion, it is evident from the records still remaining that liquid lava rose within it and breached its wall, both on its west and southeast borders. The lava which escaped westward was small in amount and now forms a pool-like sheet of black pahoehoe about 600 feet

across. Some of the lava in this pool, however, came from the crack mentioned above, along which there is situated a row of driblet cones. After the opening of a breach in the west side of the crater the opening was partially closed by a discharge of lapilli, but not rebuilt to its former height. On the southeast side of the crater the portion of its wall which has disappeared includes about one-third of its original extent, and through the break there was outpoured a flood of lava which inundated an area of about 50 square miles. The lava cooled in the breach it had formed in thin sheets, so as to produce a steep-sided ridge, which completely occupies the break and unites with the remaining fragments of the lapilli and cinder cone at each end. This ridge of lava is of the same nature as the walls of typical lava cones, being formed of thin sheets of highly vesicular rock, each one seemingly formed by the congealing of a thin overflow from the crater and succeeded by another similar overflow, until a steep ridge composed of overlapping lava sheets was produced. The main discharge of lava took place beneath the crust thus formed, after the manner so common in highly liquid lava streams, and escaped through tunnels.

The final drawing off of the molten material, which once filled Crater No. 4 up to the level of the top of the rim of congealed lava on its eastern side, allowed the crust of scoriaceous and ropy pahoehoe lava formed within it to subside, and although in part broken it still rests at the bottom of the irregular pit it left about 100 feet lower than its former position. Since the subsidence of the floor of the crater there has been some tumbling in of its unsupported walls, but the cakes of corrugated lava on its floor are still to a large extent unconcealed.

The rise of liquid lava within a cinder and lapilli cone, as in the example just described, the building of a raised rim in the breach in the crater walls composed of fragmental material, and the subsequent lowering of the lava crust formed on the pool within the crater are all features which are found in numerous volcanoes in Idaho and Oregon which built lava cones. The greater number of the lava cones that have been examined, however, are situated on generally plain surfaces, and the floods of outwelling highly liquid rocks, which were extruded from them, spread in all directions, and the cinder and lapilli cones, which probably in all the instances referred to were formed at an early stage in the eruptions, were completely destroyed or buried. In the instance here considered, however, owing to the inclination of the surface on which the volcano originated, the lava extruded flowed almost entirely in one direction, leaving a large portion of the preceding cinder and lapilli cone intact. No. 4 of the Jordan Craters is thus in part a cinder and lapilli cone and in part a lava cone. Had the slope down which the lava flowed been steeper it is probable that the liquid rock would have flowed away too quickly for a lava ridge to have been formed about the pool in the summit of the conduit from

which it came, a condition illustrated by the Martin lava stream and other similar outwellings of lava in mountainous regions described in Bulletin No. 199.

Driblet cones and "ovens."—The extrusion of liquid or highly plastic lava from cracks or other openings in the crusts formed on lava, as in the craters of certain of the Hawaiian volcanoes, has been described by J. D. Dana,[a] and the hollow cones, towers, etc., produced by drops or clots of ejected material which adhered one to another, have been designated driblet cones. Interesting examples of structures of this general nature occur along the fissure mentioned above, which extends westward from the most northern of the Jordan Craters.

Situated on the fissure referred to are 10 or 12 oven-shaped piles of lava clots, some of which are more or less confluent, so that a definite count is impracticable. These piles are nearly circular, with rounded summits, and range in height from 15 to probably 25 feet, and are hollow within. Some of the examples are still unbroken, and are either completely roofed over or have rudely circular openings at the top, while others are broken and prevent free examination of their interiors. One characteristic example, shown in Pl. XI, *A*, is about 20 feet high on the exterior, between 40 and 50 feet in diameter at the base, and within contains a symmetrical level-floored chamber, with dome-shaped roof, measuring 14 feet in diameter at the bottom and 17 feet in height. The walls of this "oven" are about 12 feet thick at the base, and diminish gradually toward the roof, which is from 4 to 6 inches thick. This beehive-like pile, and others similar to it, are plainly of the nature of driblet cones, but on account of their shapes may perhaps be termed driblet ovens. Their formation, as has been explained by Dana in reference to similar structures observed in the Hawaiian Islands, is due to the blowing out of plastic lava from an orifice and the piling up of the adhering clots about the place from which they came. The hollow chimney-like forms thus produced were gradually contracted at the top until, in some instances, they became completely roofed over. On the interior of these structures the lava hangs in pendant stalactite-like masses, usually of a deep-reddish color, and from a few inches to 2 feet or more long.

Examples of similar driblets cones of smaller size occur on a lava flow that came from the Diamond Craters, to be described later, two of which are shown on Pl. XI, *B*. Driblet cones are also present at the Cinder Buttes, but in this case are chimney-like piles, termed on a previous page parasitic cones. One example at the Cinder Buttes, however, now partially destroyed, has the oven-like shape so characteristic of the example present at the Jordan Craters.

Lava "gutters."—About the bases of the driblet ovens associated with Crater No. 4 of the Jordan series, and also at the east base of the crater itself, there are localities where lava flowed in narrow

[a] Characteristics of Volcanoes, New York, 1890.

A. DRIBLET CONE OR OVEN, JORDAN CRATERS, OREGON.

B. DRIBLET CONE, DIAMOND CRATERS, OREGON.

streams down moderately steep slopes and made for itself well-defined channels. These channels are, in general, about 3 feet wide, 3 to 4 feet deep, with the crests of their bordering ridges elevated about 3 feet above the adjacent surface, and from 50 to 150 feet long. One example of these troughs or gutters, situated at the south base of the driblet cone shown on Pl. XI, *A*, is about 50 feet long, 14 to 16 inches wide, and 3¼ to 4¼ feet deep; the crests of the bordering ridges are, in general, 3 feet above the adjacent surface. Near its distal extremity the trough is completely roofed over, as may be seen in the illustration just referred to. The largest example observed is situated on the east side of Crater No. 4, and is about 150 feet long, 3 feet wide, with well-defined walls, which rise approximately 3 feet above the neighboring surface. These and other similar gutters usually begin abruptly at their upper ends and retain a nearly uniform width and depth to near their distal extremities, where their walls become lower and the troughs merge with broadly expanded, low, dome-shaped elevations on a general pahoehoe surface. In some instances the liquid lava, as it flowed through one of these gutters, became cooled at the surface so as to form a crust, which was left as a slightly arched roof above a tunnel as the still-liquid lava beneath flowed out. These gutters with roof are in fact tubes or tunnels. In the instance shown in Pl. XIV, a well-defined gutter was formed, in which the lava flow decreased until the surface of the current was about 3 feet below the crest lines of the inclosing ridges; a crust was then formed, and the lava below it flowed out, leaving a roof spanning the gutter throughout its length.

The mode of formation of lava gutters seems to be that a narrow stream of liquid lava cools at its margins and forms a slight ridge, more lava spreading laterally over this ridge, in turn cools and stiffens, and then adds to its height, and so the process continues until a well-defined gutter with raised borders is formed. These parallel ridges on the borders of a narrow, high-grade lava torrent are in a measure analogous to the natural levees built by alluvial-depositing streams.

Lava flow.—The lava from Crater No. 4 of the Jordan series, as already stated, flows southeastward over a previously stream-eroded surface. The lava, just after leaving the crater from which it came, formed a stream 545 yards wide, and increasing rapidly in width reached a distance of about 8 or 10 miles. The entire flow is by estimate between 50 and 60 square miles in area. The average depth may perhaps be taken as approximately 100 feet. These statements, it must be remembered, are rough estimates, as no surveys have been made, and no maps of the region are available. The lava as it advanced was guided in a conspicuous way by the preexisting topography, and in several instances progressed short distances up lateral valleys tributary to the main depression down which it flowed. One of these small offshoots went nearly due north for one-half mile up a small

stream valley until its progress was checked by the rising gradient. In places the fresh, black lava is bordered by rims of older rock, showing that small canyons in the preexisting surface had been nearly filled. Near the eastern limit reached by the lava it ascended the small canyon of Cow Creek for about 1 mile, and on cooling formed a dam, which now retains the largest and most northern of the Cow Creek lakes, as has been described on a previous page. About its southeastern margin there are several other lakes.

This great lava stream or lava sheet came from a small crater, termed above Crater No. 4, the bottom of which is approximately 300 feet across. Seemingly the actual conduit must be of still smaller diameter. This effusion of highly liquid lava, with only mild explosions at the beginning of the discharge, is a typical illustration of the manner in which many extensive lava sheets of Idaho, Oregon, and Washington were poured out. The lava from Crater No. 4 seems to have progressed mainly by flowing beneath a stiffened crust, and in this manner was prevented from cooling quickly, thus permitting it to advance far and spread widely. Tunnels in the lava were produced by the outflow beneath the crust formed on its surface, and in certain places, as near the source of the stream, the roofs of such tunnels have fallen in, leaving irregular pits with overhanging walls from 50 to 70 feet deep.

In many portions of the lava flow pressure ridges and domes like those so common in the immense lava sheets about the Cinder Buttes, in the older sheets of Snake River lava, and at other places, are well displayed. A photograph of one of these domes, situated near the northern border of the lava sheet, and midway between its source and the most northerly of the Cow Creek lakes, is reproduced on Pl. XV, *A*. A similar ridge on a lava sheet of somewhat older date, which came from the Diamond Craters, is shown on Pl. XV, *B*. That the lava in each of these instances was horizontal before being pressed up into dome-like ridges, is shown by the corrugation on the surface of the dome, to be seen in Pl. XV, *A*, and of the columnar structure in Pl. XV, *B*.

DIAMOND CRATERS.

A group of recently extinct volcanoes which it is convenient to term the "Diamond Craters" is situated in the east-central part of Harney County, Oreg., about 6 miles west of Diamond post-office. The craters, about 20 in number, occupy an area of about 5 square miles, and are surrounded by at least 30 square miles of rough lava which flowed from them.

The Diamond Craters are situated near the base of the long west slope of Stein Mountain, and came into existence after the land over which they discharged their lava had been deeply dissected by erosion. The lava entered the valleys and canyons and obstructed the drainage so as to cause swamps to form. A significant fact in this

connection is that the basins above some of the lava dams are still unfilled and have never been occupied by water bodies except ephemeral or playa lakes. This evidence seems to show that the climate of the region has been as arid as at present ever since the lava streams obstructed the drainage.

The Diamond Craters are of two types, namely, lapilli cones and lava cones, the lapilli cones situated in the southwest and the lava cones in the northeast portion of the group. The lapilli craters are mostly low, and range in size from one measuring about 2,500 feet across to small conical piles of brownish débris. Within the largest crater there are hills and mounds of lapilli of the same character as the material forming its encircling rim, but rising to a height of from 50 to 75 feet above it. This great accumulation of fragmental material presents an uneven surface consisting of hillocks and crater-like hollows and bears evidence of the occurrence of weak explosions in a crater so abundantly charged with débris that it could not clear itself. From analogy with streams, the volcano may be said to have been overloaded with débris. The fragmental material was blown up into hills, and crater-like pits opened in it, but the escaping lava did not have sufficient force to eject it from the crater.

The hills and rings of lapilli among the Diamond Craters present many variations. Some are simple conical piles of the normal type, with depressions in their summits; in others lava rose and, breaching the inclosing wall, overflowed. In one instance the lava, after rising in a crater and outflowing, was drawn off beneath the crust formed on its surface and within the bowl of lapilli, about 600 feet across, causing the crust to fall in and leaving a black, irregular gulf 30 feet deep, and one lapilli ring or crater has another, composed of the same kind of material, within it, thus recording two stages of activity. In one instance a small crater is composed of compact, spherical lava balls or bombs, ranging in size from about 2 inches to the size of small shot. These bombs are rough, of a dull-red color, not cellular, and exhibit no evidence of rotation excepting their well-rounded shapes. Bordering the lapilli craters on all sides are the broad, rough surfaces of recent lava fields, which in most instances are covered to some extent with sagebrush and other vegetation.

To the north of the lapilli craters and merging with them as topographic forms are rounded hills composed of lava sheets, which furnish examples of lava cones. The highest of these hills rises about 400 feet above the adjacent plains and is the highest and most conspicuous summit in the group of which it is a member. This central dome is about 1½ miles in diameter, and so far as is indicated by the exposures is composed throughout of lava sheets, which occupy its summit and descend its sides in all directions to the surrounding plain. There is no true crater to be seen, but at the summit of the hill there is a gulf, due to the falling in of a large block of lava of

which the surface of the hill is composed. This gulf has a nearly vertical wall from 40 to 70 feet high, runs about east and west, is from 500 to 800 feet across, and fully 2,000 feet long. Within it are several irregular ridges formed by the edges of large tilted blocks of the fallen crust. The lava exposed in the walls of the break is irregularly columnar, and the topmost layer, which arches over the summit of the hill, is about 40 feet thick. This sheet is continuous from one side of the hill to the other, passing over the summit, but in the central part of the dome thus formed the rock is highly scoriaceous and the bedding less distinct than at the sides. From the gulf in the summit of the hill branching fractures extend down its sides to the east and southeast, and in part these radiating breaks are gulfs produced by the subsidence and tilting of large blocks of the surface layer. To the north of the hill just described there are other elevations of a similar nature, but lower and less broken, and about the group there are rough lava flows, which came from it and spread over the previously eroded land. On one of these lava sheets there are small driblet cones, two of which are represented on Pl. XI, *B*.

The interpretation of the facts in reference to the domes of lava briefly described above seems to be that from certain of the Diamond Craters, which were probably lapilli cones like those of that nature still remaining, great quantities of lava were extruded in a liquid or plastic condition, which buried or carried away the preceding craters of lapilli and, thickening about the opening from which it came, built up rounded hills. The outwelling lava flowed down the sides of the hill and a thick crust was formed on its surface. After this, the outflow continued beneath the stiffened surface, and finally, when no more lava rose from the conduit beneath, a considerable portion of the surface crust fell in, leaving the black gulf now forming such a conspicuous feature of the summit and eastern side of the largest dome. The smaller lava cones or domes to the north of the principal cone were less fractured than the main one of the series, and retain nearly all of their constructional features unmodified by either fracture, subsidence, or erosion. In fact but slight changes by erosion are anywhere visible throughout the entire group of craters.

The rounded hills of lava among the Diamond Craters are, as may be judged from the description just given, examples of lava cones, and are similar to many other elevations in Idaho and Oregon, which were produced in each case by the escape of lava in large volume from a volcanic conduit. The chief differences between the lava cones here considered and those of the normal type are the prominence of the rounded central hills and the comparatively small extent of the surrounding lava fields with which they merge. The usually characteristic profile presented by lava cones, consisting of long, gentle slopes leading up to a low central flat-topped butte, is not present. In this connection it may be suggested that the lava poured out to

form the hills referred to was less liquid and did not flow away so readily, as in many other similar instances, but thickened in a more conspicuous manner than normally about the openings from which it came.

In the formation or lava cones, as is the case with the flow of lava streams generally, an important condition, and the one which makes it possible for a small hill to form with a sheet of lava extending completely over its summit, is the subsurface flow of liquid or plastic lava beneath a stiff crust. The degree to which lava escapes in this manner from a deep accumulation determines the extent to which its surface will be fractured and the amount of surface change which will result from tne subsidence of fragments of the crust.

BOWDEN CRATER.

Situated in the south-central part of Malheur County, Oregon, and about 6 miles northeast of the former post-office of Bowden, there is an isolated volcanic crater surrounded by an extensive lava flow, which it is convenient to designate the Bowden Crater.

The region about Bowden Crater is composed largely of Tertiary lacustral deposits, and was deeply eroded before the eruption which built the crater. The region, in fact, had all of its present erosion features at the time referred to, and has been but slightly modified since the volcano ceased to be active.

Bowden Crater and the lava flow about it are composed of basalt. There is, so far as observed, a complete absence of the products of explosive eruptions, such as lapilli, volcanic bombs, etc. The crater rises 600 feet by aneroid measure above the plain at the margin of its lava flow, but the lava flow and crater merge with each other, and the rise from the outer margin of the lava to the base of the cone in the center of the broad, black, desolate tract of fresh rock is exceedingly gradual. The upward slope for the first 3 or 4 miles is less than 1°; then for about 2 miles it gradually increases to perhaps 2° or 3°, and on the sides of the central and circular elevation becomes about 10°. The height of the central elevation above the surrounding lava is approximately 200 feet. The walls of the crater are of lava of the same general character as that forming the extensive sheet about it, but is perhaps somewhat more scoriaceous. The raised rim of the central elevation inclosed a steep-sided circular basin, 600 feet in diameter and about 40 feet deep. The bottom of the depression is level floored and consists of fine light-colored silt, most probably of eolian deposition. During the wet season this depression is converted into a shallow lake, which evaporates to dryness in summer.

When standing on the summit of Bowden Crater no other similar elevation is in sight, and no other volcanic vent has as yet been discovered nearer than the Jordan Craters, situated about 30 miles to

the northeast. It is thus evident that the surrounding lava flow came entirely from this single and relatively small center of eruption. The lava flow referred to surrounds the crater on all sides, but extends farthest to the northwest, or in the direction of drainage of the region before the lava was spread out. The area of the lava field is by estimate fully 100 square miles. The thickness, on the supposition that it was spread out on a nearly level plain—which was apparently the case—varies from but a few feet at the margin to about 400 feet at the center. The surface of the lava is rough, and many pressure ridges are present, particularly within a radius of 2 to 3 miles of the crater. Considerable weathering has occurred, and in general the entire lava flow, as well as the sides and bottom of the crater, is overgrown with sagebrush, bunch grass, and other vegetation. On its southern border the lava field dammed Rattlesnake Creek, and caused a lake of considerable size to form. The bed of this lake has been filled to a depth of at least 40 feet with fine alluvium, and, owing in part also to the lowering of its outlet by erosion, is now dry and occupied by natural meadows of rye grass.

Bowden Crater, as may be judged from the facts just mentioned, is a typical and most instructive example of a lava cone of the variety having a crater at the top. This crater is circular, and not an irregular gulf, produced by the breaking and partial subsidence of a dome of lava, as in the case of the highest of the Diamond Craters. The precise manner in which the crater's rim was built up is not clear, but apparently it was formed by the radial overflow of lava in thin sheets. The central part is perhaps due to a drawing off of the molten rock which once occupied it, through tunnels in the surrounding lava. It is possible, in this and other similar instances, that a circular cinder rim was formed about the summit of the conduit from which the lava rose by the cooling and running together of splashes of liqui lava. Craters formed in this manner would furnish a connection between those composed of lapilli and scoria and true lava domes, like the highest of the Diamond Craters.

SUMMARY.

The various phases of volcanic eruptions illustrated by the Cinder Buttes and by the Jordan, Diamond, and Bowden craters are such as pertain in general to volcanoes which, for the most part, discharge highly liquid lava. At each of these volcanic centers it seems that the first eruptions were of the explosive type, and that the elevations produced by the accumulation of projectiles—whether solid, plastic, or liquid—first formed were, to a considerable extent, and in some instances completely, buried by the subsequent quiet effusion of vast quantities of liquid lava. Among the more interesting of the minor phenomena associated with them are the craters which were built of ejected angular fragments which were blown out from the cooled and rigid lava at the summits of the volcanic conduits, and similar struc-

A. FISSURED PAHOEHOE LAVA, JORDAN CRATERS, OREGON.

B. AA LAVA SURFACE, CINDER BUTTES, IDAHO.

A.

B

MARGINS OF LAVA FLOWS, CINDER BUTTES, IDAHO.

tures formed of material which was ejected in various conditions ranging from extreme viscosity to liquidity, and which formed scoria, bombs, lava cakes, and splashes of lava which became confluent after falling. The elevations built by the accumulation of such projectiles range, as has been stated, from lapilli cones or craters, due to the piling up of solid angular fragments, through similar craters composed in part or perhaps wholly of clots of plastic lava, volcanic bombs, and lava cakes to driblet cones and "ovens." The range in angle of slope on the exterior of these structures is from the neighborhood of 30° for the loose angular fragments to nearly vertical for the adhering clots; the range in slopes of the interior of the crater walls is about the same as for the exterior. When the driblet cones are roofed over, their inner slopes, both on the outside and within, pass beyond the vertical and approach the horizontal.

The lava flows also present a wide range in the resulting details, such as typical pahoehoe (Pl. XII, *A*) with corrugated surfaces, and even hollow folds due to the influence of an underflow beneath a plastic crust, and equally typical *aa* (Pl. XII, *B*), due to the breaking of a rigid crust on account of the energetic flow of still liquid lava beneath it. The occurrence of lava gutters (Pl. XIV) and the presence, in numerous instances, of prominent pressure ridges on the recent lava sheets (Pl. XV, *B*) are also instructive features. The thin margins of liquid lava streams and the conspicously abrupt and rugged extremities of highly viscous lava flows are illustrated on Pl. XIII.

All the material extruded from the volcanoes described above is basalt, and represents the more easily fusible of lavas.

In many ways these modern volcanoes serve to illustrate the nature of the far larger outporings of molten rock which, on cooling, formed the Snake River Plains and the still vaster, but, in part at least, somewhat differently erupted Columbia River lava. In a general discussion of volcanoes the Cinder Buttes, etc., may be considered as representing volcanoes of the quiet type, or such as erupt without energetic explosions, but their periods of activity were in all cases, so far as can be judged, initiated by explosions sufficiently violent to blow out projectiles, which on falling formed conspicuous elevations. They may be considered, therefore, as furnishing a connecting link between volcanoes of the explosive and those of the quiet type. These intermediate examples indicate, as has long been recognized, that the classification of volcanoes under two types, viz, explosive and quiet, is largely for convenience and that no sharply defined boundary separates the two.

TERTIARY FORMATIONS.

Besides the products of recent volcanoes, briefly described in the preceding pages, there are, in the portions of Idaho and Oregon under consideration, widely extended sheets of rock which may be classified according to their mode of origin in two broad groups of terranes, one of which includes the rocks composed of material that was deposited

by water and the other the rocks which have cooled from a molten condition. The former includes the material laid down in lakes and by streams, aided in each case in a minor way, no doubt, by the transporting action of the wind; and the latter embraces the various products of volcanoes or volcanic rocks, and the similar magmas which have cooled in fissures, below the earth's surface, forming dikes. These more general groups of rocks are naturally subdivided in reference to mode of origin, composition, etc., as is indicated in the following table:

1. Sedimentary rocks	Conglomerates, sandstones, shales, unconsolidated gravel, sand, clay, etc. (together with beds of volcanic dust and volcanic gravel or lapilli).		
2. Igneous rocks	a. Volcanic rocks	Lava flows	Basalt.
			Rhyolite.
		Fragmental products of volcanoes.	Basaltic scoria, bombs, lapilli, etc.
			Rhyolitic lapilli and dust.
	b. Dike rocks	Magmas like the molten material discharged by volcanoes, but which cooled in fissures below the earth's surface, forming dikes.	

All the rocks referred to above are placed provisionally in the Tertiary division of geological history, excepting, as already noted, in the case of certain of the products of volcanoes which are of later date, and belong to the Pleistocene and recent times. The sedimentary rocks of Tertiary age also grade into more recent deposits of similar character and like mode of origin. At present it is impracticable to designate any well-defined boundary between either the volcanic or sedimentary rocks of the Tertiary and the similar terranes of more recent origin. While terranes older than the Tertiary are certainly present beneath the areas occupied by rocks of that age, they are believed not to be exposed at the surface along the route followed during the reconnaissance which furnished the data for this report.

SEDIMENTARY ROCKS.

The stratified rocks of the region examined—or those composed of fragments of older rocks, spread out in layers or strata by the waters of lakes and streams—comprise conglomerate or pudding stone, sandstones, soft, highly calcareous, usually nearly white, shales, and loose gravel, sand, white volcanic dust, and dark usually yellowish volcanic gravel or lapilli. These beds were for the most part deposited in lakes, and belong to the Tertiary division of geological history.

Examples of the conglomerate and sandstone referred to may be seen in the hills near where the Owyhee joins Snake River, in the isolated hills near Vale, and in the conspicuous bluffs to the southeast of Malheur and Harney lakes, as well as many other localities. These

A.

B.

LAVA GUTTERS, JORDAN CRATERS, OREGON.

A. PRESSURE DOME IN RECENT LAVA, JORDAN CRATERS, OREGON.

B PRESSURE RIDGE IN RECENT LAVA, DIAMOND CRATERS, OREGON.

A. WEATHERING OF THIN SHEET OF BASALT ABOVE SOFT STRATA, MULE, OREG.

B. WEATHERING OF THICK SHEET OF BASALT ABOVE THICK BEDS OF SOFT MATERIAL, SNAKE RIVER CANYON, OPPOSITE ENTERPRISE, IDAHO.

rocks are usually dark yellow, but occasionally, as near Narrows, are nearly white, and in some instances are sufficiently compact to be used for building stone. Associated with the layers of consolidated pebbles and sand just referred to, and having a wide extent in both Idaho and Oregon, are soft unconsolidated light-colored shales and marls and thick beds of nearly white sand and light-colored clay. Beds of this general nature aggregating more than a thousand feet in thickness underlie the Snake River between Glenns Ferry and Weiser and form the conspicuous white bluff along each side of that stream. Similar beds occur also in the lower portion of the valley of Malheur River and beneath the rim rocks of the canyons on the west slope of Stein Mountain. Light-colored and in part greenish shales outcrop on the west side of Alvord Valley, where they pass beneath the sheets of basalt, forming the bold eastern face of Stein Mountain. Fine exposures of rain-sculptured lacustral sediments, usually of a peculiar light-greenish tint, occur on the border of Owyhee River, near the mouth of Jordan Creek (Pl. XVIII). Similar beds are present also in the mountains of Owyhee County, Idaho, and are a southward extension of the thick sediments exposed along Snake River. This same formation extends northward from Snake River and is exposed near Boise and in the valley of Payette River. From its abundant exposures along the last-named stream it has been named by Waldemar Lindgren the Payette formation.

While the Payette formation has a wide extent in Oregon, and possibly reaches to the John Day River, where other similar beds outcrop and have been independently named, it is not positive that all the exposures of similar material as far south as Harney and Silver lakes were deposited in the same lake basin. The lacustral sediments beneath the basalt of Stein Mountain reveal a thickness of fully 1,000 feet, and, as seems probable, are of older date than the Payette formation.

Interbedded with the sandstone and shale, of the formations just mentioned, and frequently forming a considerable and at times seemingly the major part of their thicknesses, are beds of exceedingly fine white volcanic dust. This dust was blown out of volcanoes while in a state of violent eruption, and, falling in lakes, or being washed into them by streams, became interbedded with other sediments or intimately commingled with them. Examples of pure white volcanic dust from 10 to 20 or more feet thick may be seen in the hills on the lower course of Owyhee River, a few miles south of Owyhee, and are also splendidly exposed near Beulah (Pl. XVII). Outcrops of material of the same nature, conspicuous on account of their whiteness, occur beneath the rim rock near Diamond, in the borders of the small valleys in the northern portion of Owyhee County, Idaho, as well as at a large number of localities in the bluffs bordering Snake River.

An interesting fact in connection with the stratified beds briefly described above is that they contain the bones of animals which are now extinct, but which lived in large numbers in and about the ancient lakes in which the sand, clay, volcanic dust, and other rocks now exposed and eroded into hills and valleys were deposited. In these same beds, but most abundant in the thinly laminated white silts and sheets of fine volcanic dust, occur fossil leaves, frequently in great abundance, and less commonly the fruits of the plants to which they belonged. These plant remains differ from the vegetation living on the earth to-day, and reveal the nature of the luxuriant forests that flourished in the now arid portions of the far West during the Tertiary period of geological history. The fossil bones and impressions of leaves and fruits referred to are of great scientific interest, as they furnish evidence in reference to past climatic changes and the gradual evolution of life on the earth, and also enable geologists to determine the relative age of the beds in which they occur.

Small collections of beautifully preserved fossil leaves were obtained from beds of fine white silt near Beulah, in the northwestern portion of Malheur County, Oreg., and from well-exposed and in part indurated sediments of Lake Payette, on Succor Creek, in Oregon, about 2 miles west of Rockhill, in Idaho. These specimens have been studied by F. H. Knowlton, paleobotanist of the U. S. Geological Survey, from whose manuscript report the following facts and interpretations of their meaning have been taken:

"The fossil plants collected contain, in addition to several species not as yet described, examples of broad-leaved trees, such as the oak (*Quercus*), of which there are several species, maple (*Acer*), plane tree or buttonwood (*Platanus*), willow (*Salix*), together with representatives of the bearberry (*Barberis*), wax-myrtle (*Myrica*), senna (*Cassia*), and others. The genera of plants represented are nearly all still living in America, but the species and varieties differ almost wholly from their modern descendants. The genera named above, as will at once be recognized by the inhabitants of the arid portions of Idaho and Oregon, are not now characteristic of that region. The leaves discovered in the rocks indicate that the trees and plants on which they grew required a more humid and in general less changeable climate than now prevails where their fossil remains are entombed. The nearest analogy of the flora they represent is seemingly furnished by the varied and beautiful vegetation of the Lower Mississippi Valley. Among the most conspicuous of the leaves spread out in the fine-grained lacustral sediments, in which they have been preserved for countless years, as if in the presses of an herbarium, are broad, strongly-veined, deeply-lobed leaves of an ancient maple, and in association with them are finely preserved winged seeds belonging to the same genus and possibly the same species. Several species of oak, etc., show that the uplands were clothed with hardwood trees, inter-

A.

B.

EXPOSURES OF VOLCANIC DUST OF TERTIARY AGE, NEAR BEULAH, OREG.

A.

B.

EXPOSURES OF TERTIARY LAKE BEDS, OWYHEE RIVER, OREGON.

spersed among which were evergreens, as may be judged from the evidence furnished by impressions in the rocks of the cones of *Glyptostrobus*, a genus of conifers not now found living in America, but still surviving in China." The species from this varied and beautiful flora identified by Knowlton are as follows:

From Beulah: *Acer*, sp. ?; *Cassia obtusa?* Knowlton; *Glyptostrobus?* species probably new; *Salix dayana* Knowlton; *Salix perplexa* Knowlton. From Succor Creek: *Acer* sp. ? *Berberis simplex* Newberry; *Myrica lanceolata* Knowlton; *Quercus breweri* Lesquereux; *Quercus consimilis* Newberry; *Quercus simplex* Newberry; *Quercus* sp. near *Q. idahoensis* Knowlton; *Platanus aspera* Newberry; *Sapindus* sp. ? and several apparently new species.

From the evidence furnished by these fossils, it appears that the plant-bearing beds on Succor Creek are a part of the Payette formation, named and described by Waldemar Lindgren,[a] which is now placed in the Upper Eocene instead of Upper Miocene as formerly.[b] The plant-bearing beds at Beulah are younger than the Payette, and, although the evidence is not all that could be wished, are referred to the Upper Miocene (corresponding with the Mascall beds of Merriam, in John Day Valley, Oregon).

The significance of the fossil plants catalogued above can perhaps be best suggested to the general reader by directing attention to an instructive, but now nearly forgotten, essay on the ancient lakes of the western portion of the United States, by J. S. Newberry,[c] one of the distinguished pioneers who made known the marvels of the Pacific mountain region.

The graphic pen picture given in the following quotation applies to the now arid valleys of Idaho and Oregon, in which the plant-charged sediments of ancient lakes are preserved, and should serve to awaken a deep interest in the minds of the people inhabiting that region in reference to the history of the land of their birth or adoption.

The pictures which geology holds up to our view of North America during the Tertiary ages are in all respects but one more attractive and interesting than could be drawn from its present aspects. Then a warm and genial climate prevailed from the Gulf to the Arctic Sea. The Canadian highlands were higher, but the Rocky Mountains lower and less broad. Most of the continent exhibited an undulating surface, rounded hills and broad valleys, covered with forests grander than any of the present day, or wide expanses of rich savannah, over which roamed

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[a] Descriptions of the Payette formation, together with discussions as to its geological age, may be found in the following publications by Waldemar Lindgren: The mining districts of the Idaho Basin and the Boise Ridge, Idaho: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 617-736; The gold and silver veins of Silver City, De Lamar, and other mining districts in Idaho: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, pp. 65-256; The gold belt of the Blue Mountains of Oregon: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 2, 1902, pp. 551-776.

[b] The evidence which necessitated a revision of the conclusions presented in the papers by Lindgren, just referred to, in reference to the geological position of the Payette formation, is presented by F. H. Knowlton in Bull. U. S. Geol. Survey No. 204.

[c] The ancient lakes of Western America; their deposits and drainage: Preliminary report of the U. S. Geol. Survey of Wyoming and portions of contiguous Territories, by F. V. Hayden, Washington, 1872, pp. 338-339.

countless herds of animals, many of gigantic size, of which our present meager fauna retains but a few dwarfed representatives. Noble rivers flowed through plains and valleys, and sea-like lakes, broader and more numerous than those the continent now bears, diversified the scenery. Through unnumbered ages the seasons ran their ceaseless course, the sun rose and set, moons waxed and waned over this fair land, but no human eye was there to mark its beauty nor human intellect to control and use its exuberant fertility. Flowers opened their many-colored petals on meadow and hillside and filled the air with their perfumes, but only for the delectation of the wandering bee. Fruits ripened in the sun, but there was no hand there to pluck nor any speaking tongue to taste. Birds sang in the trees, but for no ears but their own. The surface of lake or river was whitened by no sail nor furrowed by any prow but the breast of the waterfowl, and the far-reaching shores echoed no sound but the dash of the waves and the lowing of the herds that slaked their thirst in the crystal waters.

Life and beauty were everywhere, and man, the great destroyer, had not yet come; but not all was peace and harmony in this Arcadia. The forces of nature are always at war, and redundant life compels abundant death. The innumerable species of animals and plants had each its hereditary enemy, and the struggle of life was so sharp and bitter that in the lapse of ages many genera and species were blotted out forever.

The herds of herbivores—which included all the genera now living on the earth's surface, with many strange forms long since extinct—formed the prey of carnivores commensurate to these in power and numbers. The coo of the dove and the whistle of the quail were answered by the scream of the eagle, and the lowing of herds and the bleating of flocks come to the ear of the imagination mingled with the roar of the lion, the howl of the wolf, and the despairing cry of the victim. Yielding to the slow-acting but irresistible forces of nature, each in succession of these various animal forms has disappeared, till all have passed away or been changed to their modern representatives, while the country they inhabited, by the upheaval of its mountains, the deepening of its valleys, the filling and draining of its great lakes, has become what it is.

IGNEOUS ROCKS.

Volcanic rocks.—The rocks which came from volcanoes are by far the most conspicuous of any of the formations in southwestern Idaho and adjacent portions of Oregon, and are apparently of greater extent and thickness than the associated sedimentary beds. They may, with sufficient accuracy for the purpose in hand, be classified as basalt and rhyolite, but a more critical study than has as yet been practicable will perhaps show that each of these divisions, and particularly the one here termed rhyolite, includes material that can with greater propriety be otherwise classified.

Both the basalt and the rhyolite present two conspicuously different phases, due to the manner in which the material was spread out on the earth's surface. In each case the rock while molten was in part extruded by volcanoes so as to form sheets which, in many instances, flowed far and wide over the surface of the land before cooling; and in part the lava while yet in the conduits cooled sufficiently to become rigid and was shattered by steam explosions. The fragments thus produced were blown into the air and widely distributed

through the action of the wind, as sheets of volcanic dust, volcanic gravel, or lapilli, and angular fragments frequently of considerable size.

The basalt was spread over the surface of the land mostly in a molten and even highly fluid condition, and the beds of fragmental material produced are relatively small; while the rhyolite to a great extent was shattered at the time it was erupted, and the resulting beds of fragments were probably of greater extent and thickness than the sheets of the same material which were spread out as lava flows. This difference in the behavior of the volcanoes from which the comparatively fusible basalt was erupted, and of the volcanoes from which the more refractory rhyolite was discharged, is of much significance in reference to the nature of volcanoes, but can not be discussed at this time.

The basalt is a black, compact rock, but is frequently cellular on account of the presence of steam cavities, and in many localities is columnar. In the region under review it occurs in widely extended sheets which in general vary in thickness from about 20 to 80 feet. Fine examples may be seen all along Snake River, but more especially on the northern side of its canyon, in the canyon of Bruneau River, and in the hills and mountains of Malheur and Harney counties, Oreg. The finest exposure of basalt in the region visited by me in 1902, if not the most remarkable in the world, is to be seen in Stein Mountain. The eastern slope of that splendid mountain is composed of the broken and eroded edges of sheets of basalt, which dip westward at an angle of about 3° and present an aggregate thickness of not less than 5,000 feet. Between the sheets of basalt, as already noted, there are in at least 18 instances beds of coarse sandstone, varying in thickness from a few inches to 6 feet. Where the beds of sandstone occur the sheets of basalt are in general about 60 feet thick. From this and other similar evidence the total number of lava flows which occur in Stein Mountain is estimated at between 80 and 100.

The widely extended sheets of basalt just referred to, like the sedimentary beds with which they are intimately associated—the sheets of basalt and the beds of sandstone, shale, clays, etc.—belong principally to the Tertiary period of geological history and, as seems evident, form the lowest member of the widely distributed formation termed the Columbia River lava. Volcanoes have been active, however, in Idaho and Oregon at intervals from the time the oldest sheets of basalt were poured out in a molten condition down to almost the present day, as is shown by the Cinder Buttes, Jordan Craters, and other volcanic features already briefly described.

The rhyolite, like the basalt, occurs both as massive sheets, formed by the cooling of molten rock, and as fragmental deposits, which also form well-defined beds. Of the layers of rock originating in these two ways, the sheets composed of angular fragments, now in many

instances firmly cemented, and forming a rhyolite tuff, are far more numerous and more extensive than the associated rhyolitic lava sheets. The beds of white volcanic dust described above as forming a part of the sedimentary deposits are composed of the finest of the fragments blown into the air by the volcanoes from which came the material now forming the sheets of rhyolite and of rhyolitic tuff.

The compact massive rhyolite is lighter colored than basalt, and in Idaho and Oregon is usually purplish on fresh surfaces, but weathers to a rich brown or red. It contains conspicuous crystals and grains of quartz, feldspar, and other mineral, and hence usually appears spotted. Frequently the crystals and grains referred to exhibit a linear arrangement, such as would be produced by a flowing motion in the glassy base in which they were embedded. At times the molten material cooled too quickly for crystals to form and produced a compact black glass, termed obsidian, fragments of which occur thickly over hundreds of square miles in eastern Oregon.

The rhyolitic tuff is composed of angular fragments of the rock just described, which, in most instances, are firmly cemented, so as to form sheets that are nearly, if not fully, as resistant to atmospheric conditions as the rock which cooled from fusion without being shattered, and frequently forms "rim rocks" on the sides of canyons and valleys.

Extensive exposures of rhyolite and of rhyolitic tuff occur in the mountains on the northeast side of Harney Valley, sometimes termed the Crow Creek Mountains. The conspicuous rim rocks on each side of Rattlesnake Creek, near Harney, are of rhyolitic tuff, while certain of the beds lower down in the walls of the same canyon, usually cavernous on the weathered outcrops, are of rhyolite, which has a peculiar concentric or spherulitic structure. Again, in the bluffs of Silvies River, to the west of Burns, the edges of a thick sheet of compact tuff are well exposed, and similar rock has a wide distribution in the forest-covered mountains in which Silvies River rises. Other outcrops of tuff and of compact rhyolite occur about Silver Lake at Iron Mountain and in the Mahogany Mountains. The conspicuous rim rocks in the vicinity of Diamond are composed of tuff, and similar rock has a wide distribution in the hills near Smith and Mule.

An interesting fact in connection with the sheets of rhyolite and of rhyolitic tuff in southeastern Oregon is that they are younger than much of the basalt of the same region, and overlie it. There have been eruptions of basalt also since the youngest observed sheet of rhyolite or of rhyolitic tuff was spread out, as rim rocks of basalt above the thick deposits of rhyolitic tuff are of common occurrence.

Dike rocks.—The molten magmas which rise in volcanoes and in part overflow, so as to form lava sheets, also in part cool below the surface in the conduits of volcanoes and in fissures. Many distinctive features in the rocks produced from the same molten magma arise in this way, which it is unnecessary to consider at this time.

Both the basalt and the rhyolite which form such extensive outflows in Idaho and Oregon came to the surface through openings, as fissures, for example; and below the present surface it is to be expected that there are many fissures in which molten rock has cooled so as to form what are termed dikes. A few dikes were observed in the bold eastern face of Stein Mountain, and indicate what may be present in other localities. The dikes referred to are nearly vertical, vary in width from 20 to 60 feet, and are horizontally columnar. As is well known, dikes have frequently led to the hardening of the walls of the fissures they occupy, and for this and other reasons their presence in an artesian basin might introduce serious difficulties in the way of obtaining flowing wells. If in drilling a well the locality chosen should chance to be directly above a dike, it is probable that the well would be a failure, even if the difficulty of penetrating the usually compact and hard rock of the dike could be overcome. Where the country rock is concealed beneath deep sheets of soil, alluvial deposits, etc., it is frequently impossible to detect the presence of a dike in the rocks beneath the surface covering, unless they are encountered in drilling or making other excavations. So far as can now be judged, however, the dikes in the artesian basins described in this report are not numerous, and the chances of striking them in drilling are small. A greater danger lies in the fact that they may cut a water-bearing stratum, so as to prevent the percolation of water through it.

STRUCTURE.

By geological structure is understood, in part, the positions occupied by stratified or bedded rocks in the earth's crust. For example, sandstone, shale, etc., originally laid down in horizontal sheets, are now found to be inclined, folded, and in many instances occupy a vertical position.

The rocks, both sedimentary and volcanic, which underlie southwestern Idaho and southeastern Oregon, were at the time of their formation spread out in nearly horizontal layers, but subsequently they have been depressed in one locality and raised in another, and in certain instances crushed together so as to form great upward and downward folds. In other instances they have been broken along nearly vertical planes, and the portion of the strata on one side of the break upraised or depressed in reference to the corresponding strata on the opposite side; that is, have been faulted. Examples of the gentle tilting of previously horizontal sheets of rocks throughout great areas are furnished in the broad Snake River Plains between Glenns Ferry and Owyhee. North of Snake River the rocks are now gently inclined upward to the north, but south of the river the same beds rise when followed southward, and in the Owyhee Mountains are more than a thousand feet above the position the same strata occupy beneath Snake River. This uptilting of stratified beds is well displayed in the hills near where Snake River first crosses the

Idaho-Oregon boundary. These remnants of formerly much more widely extended strata indicate the great amount of denudation that has occurred throughout an extensive region.

Broad and comparatively gentle elevations and depressions of the once horizontally stratified rocks occur also in other portions of the region examined, as, for example, in the neighborhood of Harney and Burns. The rocks beneath the extensive valley in which Malheur and Harney lakes are situated slope upward in the hills and mountains about the borders of the basin, as is well shown in the walls of the canyons on the west side of Stein Mountain, in the Crow Creek Mountains, on the border of the canyon of Rattlesnake, in the hills to the west of Burns, and at several other localities in the same region. In general, all about the Harney Basin—as it is convenient to term the great depression in which Malheur and Harney lakes are situated, and of all of the country drained by them—the rocks are upraised. This basin, however, is not a simple saucer-shaped depression, but has irregularities, and is due to the association of several upheavals and depressions. The broad, gentle undulations in the rocks just referred to are, in some instances, a hundred or more miles across, and are promising structural features in reference to the hope of obtaining an artesian water supply.

In addition to the broad and usually somewhat indefinite swells and depressions referred to above, and others of similar nature but of smaller size, are certain well-defined upward folds or anticlines, and equally characteristic downward folds or synclines. These are similar in shape and analagous in the manner in which they were produced to the folds or corrugations that may be made by pushing one side of a pile of rugs toward its center, or, on a still smaller scale, by forcing together the sides of a pile of newspapers so as to compress them into folds. In the region under consideration there are several examples of such folds, but, as is commonly the case on all land areas, the relief of surface produced in the manner referred to has been greatly modified by erosion. The upward folds particularly have been cut away, leaving for the most part only their basement portions.

A striking illustration of a great upward bend, involving bedded lava sheets with an aggregate thickness of fully 5,000 feet, and also a great but unknown thickness of stratified sedimentary deposits beneath them, is furnished by the northern portion of Stein Mountain and the several parallel—nearly north-south—ridges to the east of it, and north of Alvord Desert. The larger features of the rugged belt of country referred to are seemingly due to the erosion of a great anticlinal fold, the longer axis of which trends about northeast and southwest, but this conclusion is here stated tentatively, as sufficient time was not available for more than a hasty examination of a part of the region. The hard layers of compact basalt in the truncated remnant of the fold now form the sharp-crested ridges

to the east of Juniper and Mann lakes, which have a gentle surface slope on one side and a steep escarpment on the other.

A characteristic example of a broad downward fold or syncline may be seen from the summit of Stein Mountain on looking southwest over the region drained by Donner and Blitzen River. The longer axis of this basin trends in a north-south direction, and is inclined downward or pitches northward.

Accompanying the deformation of rocks, breaks sometimes occur, and the edges of the broken layers on the opposite sides of a fracture are upheaved or depressed with reference to each other. In this and yet other ways what are termed faults are produced.

Breaks in the earth's crust of the nature just referred to, when they affect the relief of the surface, produce bold escarpments. The strata frequently dip away at gentle angles, thus producing what it is convenient to term monoclinal ridges or mountains—that is, elevations with steep descents on one side and gentle slopes, corresponding closely with the inclinations of the component beds, on the other. Examples of such monoclinal mountains are furnished, as seems evident from such studies of them as it has been practicable to make, by Stein Mountain and Mahogany Mountain, in Oregon.

MINERAL RESOURCES.

PETROLEUM.

Search for petroleum has been carried on in the valley of Snake River in southwestern Idaho and adjacent portions of Oregon, but these attempts have proved failures so far as the discovery of the material sought is concerned. In all of the instances referred to that have come under my notice, it is evident that little if any study of the geological conditions was made previous to drilling, and little if any appreciation of the conditions governing the accumulation and storage of petroleum seems to have been entertained by the persons who "promoted" the various oil ventures. As much time and money has been spent in the region mentioned in fruitless attempts to discover petroleum, and as additional efforts will no doubt be made in the same direction, more conservative methods may perhaps be favored if a plain statement of the general principles pertaining to the occurrence of petroleum, and of gas with which it is commonly associated, be laid before the reader.

CONDITIONS FAVORING THE NATURAL STORAGE OF PETROLEUM AND ROCK GAS.

The geologist in searching for oil and gas pools, as subterranean accumulations of petroleum and natural or rock gas are commonly termed, must of necessity be guided mainly by the physical properties of these substances; by the occurrence of water, with which they

are commonly associated; and by the characteristics of the strata in which they occur. An attempt is here made to state in nontechnical language the conclusions that have presented themselves in reference to the natural storage of petroleum and gas, as search for these substances has been carried on in various parts of the world. No originality is claimed for what follows, as it is simply a rearrangement of widely current knowledge.

The physical properties of petroleum, gas, and water are well known, and of these properties the ones of special significance to the geologist are their specific gravities. The specific gravity of petroleum in most all instances is below 1—that is, it is lighter than an equal volume of water. The range in specific gravity for American petroleum is from about 0.771 for the highly liquid yellow or amber-colored varieties to 0.945 for the thicker and frequently black material, valued principally as a lubricant. The only instance known, so far as the writer is aware, of petroleum which is heavier than water is that obtained at Zante, in Greece, which has a specific gravity of 1.02. Natural gas is far lighter than the lightest petroleum, its density being about one-half that of air. The principal physical differences between petroleum and gas are those that constitute the distinction between a liquid and a gas. The gas has the property of indefinite expansion, and when put under pressure diminishes in volume, at the same time acquiring greater expansive energy or tension.

It is the occurrence in nature of petroleum and gas with these widely different physical properties, and each of them lighter than water, with which they are usually associated, that the geologist has to consider. Not only this, but attention needs to be given to the occurrence of these substances singly or together, and of one or both of them in association with water. The physical properties of petroleum and gas thus determine some of the conditions on which success in the search for commercial quantities of these substances depends.

If water, petroleum, and natural gas be placed in a corked bottle and the receptacle be allowed to rest for a brief time, they arrange themselves in the order of their respective specific gravities, the water being at the bottom, the petroleum next above, and the gas at the top. This conclusion is self-evident, and there is no reason for thinking that the law it illustrates is violated when the three substances named are present in a cavity in the earth, or what is much more common, contained in the pores of a loose-textured rock. Then, too, the water present in the rocks is never pure, but contains more or less mineral matter in solution, and not infrequently it is highly saline. Its specific gravity is, therefore, greater than if it was pure, and its ability, under certain conditions, to displace petroleum and cause it to rise is correspondingly increased.

The displacement by water of petroleum contained in the pores of rock has certain limitations, however, which at times become important. Petroleum in porous rocks adheres to the surfaces with which

it comes in contact, this tendency being greater in the heavier than the lighter varieties, and may be only in part or not at all displaced by water. If the oil refuses to flow under the pressure of water, however, it can not be separated except by methods which at present are commercially impracticable.

Another important consideration in reference to the occurrence of petroleum and gas in the interstices of rocks, is the porosity of the rocks themselves. It has been shown by wide experience that water, petroleum, and gas, as they occur in the rocks, are generally contained in the small interstices and minute cavities between the grains or crystals, and not in caverns or open fissures. This is the nearly universal rule, not only in reference to water in artesian basins, but also for petroleum and gas in practically all the areas where they occur. Although cistern-like bodies of these substances may exist, they are certainly rare, and their presence beneath the surface can not be foretold. Their accidental discovery by the drill is a lucky chance.

The porosity of rocks varies through all degrees, from loose sand, which may absorb one-half or more of its own volume of oil, to dense, compact quartzite, granite, and limestone, which are practically impervious.

The three substances under consideration are contained in porous rocks in the same manner that water is held in a sponge or in a brick, and in the same manner, also, that water passes through a sponge or may be forced under pressure through a brick, so petroleum percolates or flows through porous rocks.

The conditions under which water, petroleum, and gas exist in porous rocks may be illustrated by packing a bottle with sponges and pouring in water and petroleum; the water, being heavier than the petroleum, will evidently find its way to the lower portion of the receptacle, and the petroleum will gather above it. If the bottle charged in this manner is placed in a warm room, or a gentle heat be applied to hasten the process, some of the petroleum will evaporate and form a gas, which will rise above the oil. If the application of heat is continued, more and more gas will be generated, and a strong gas pressure be produced. The application of the principle thus demonstrated will be considered later.

The porosity of rocks varies, as stated above, but those most commonly charged with petroleum or gas so as to act as reservoirs are sandstone, conglomerates, and certain open-textured limestones. It must not be concluded, however, that these are the only rocks that may act as storage reservoirs in this connection; any rock that has an open texture, from whatever cause, may serve the purpose. A rock may be crushed and so filled with crevices as to permit of the ready percolation of liquids; even volcanic rocks with an open scoriaceous texture might fill the rôle. In general, also, the rocks which permit of the passage of petroleum and gas are permeable by water.

The impervious rocks met with in stratified beds, which are the usual ones containing water, petroleum, and gas, are mainly shale and clay. These rocks were once in the condition of mud and silt, and are composed of very small fragments, and, moreover, on account of their consistency, are rendered compact by pressure and are frequently impervious even to gases.

The porosity of rocks thus depends on the size and shape of the grain, or crystals of which they are composed, and on the nature and amount of the cement which unites the grains; the smaller the grains and the more perfectly they are cemented together, the less the size of the interspaces between them. Pressure tends to compact the granules of rocks, and the smaller the granules the more thoroughly they may be made to fit together. The search for petroleum and gas, therefore, demands a study of the rocks in reference to their porosity. As will be shown below, the most favorable conditions, so far as rock texture is concerned, occur when a thick layer of open-textured rock, say coarse sandstone, is covered by a layer of fine-grained rocks like shale. An additional reason why sandstone and certain limestones make favorable reservoir rocks, and shales efficient covers for the reservoirs, is because the sandstones and limestones are rigid, and if fractured or jointed the cracks remain open unless the beds are under excessive pressure, while the shales, if fractured, tend to flow, even under moderate pressure, and thus close the fissures.

The source of the water with which nearly all rocks near the earth's surface are more or less thoroughly charged, is primarily the rain, although essentially all stratified beds were deposited in water and for that reason were at first water charged, but this primary water has in most instances been flooded out by subsequent underground percolation.

The source of the petroleum, as conceded, I believe, by all geologists, is organic matter contained in the rocks, but other theories to account for its presence have been suggested. The chemistry of the change undergone by organic matter when excluded from the air is not well known, but the evidence seems conclusive that plant or animal remains buried in the rocks, usually in the presence of saline water, undergo a slow spontaneous change at low temperatures, one result of which is the production of petroleum. A higher degree of heat hastens the process, but within moderate limits seemingly does not vary the nature of the result.

Petroleum at ordinary surface temperature evaporates and gives origin to inflammable gases, and an increase in temperature hastens the change, but, except at what may be termed a high degree of heat, does not vary the nature of the result. What is of special interest to the geologist in this connection is that the evaporation of petroleum and the production of gas go on at the ordinary temperatures observed in the surficial portions of the earth's crust. As light, highly liquid

petroleums evaporate, they become more and more dense and change to heavy oils; still greater loss by evaporation leads to the production of highly viscous substances, like mineral pitch; and a further change in the same direction furnishes a large variety of solid hydrocarbons.

In a general way, then, petroleum furnishes natural gas as a "distillate" and viscous and solid hydrocarbons as residues. This is as far as we need attempt at present to penetrate the wide and but partially explored field of the origin and chemistry of petroleum and its derivatives.

If we assume, as stated above, that petroleum is derived from the organic matter contained in rocks, then it follows that we may expect to find it in sedimentary rocks of any geological age which were deposited after life appeared on the earth. This conclusion is abundantly sustained by the many discoveries of petroleum and gas that have been made in rock ranging in age from the lower Paleozoic to the Tertiary and even recent time. Any series of stratified rocks, therefore, so far as its geological age is concerned, may be expected to yield hydrocarbons in one form or another, and, as has already been suggested, even igneous and metamorphic rocks may serve as reservoirs.

Fluids and gases contained in subterranean chambers, or in the interstices of porous rocks, are first of all subject to the force of gravity. Water in porous rocks will descend under the pull of gravity and displace lighter fluids, as well as gases, thus causing them to rise if avenues for escape are available. Petroleum alone, in a porous rock, will descend and seek the lowest attainable position, although the thicker varieties, owing to their high degree of viscosity, would move sluggishly.

Hence, water, petroleum, and gas in a porous rock will, as already stated, arrange themselves in the order of their respective specific gravities, the water being at the bottom and the gas at the top, and the water will be subjected to the pressure of the lighter substances resting on it. When porous rocks charged with the three substances named are confined by impervious beds, so that an escape for the gas is impossible, the water and the oil must be pressed on by the gas, owing to its tension or expansive force; and should gas continue to be generated, it will acquire such a tension as to exert a great pressure on the fluids imprisoned with it. The fluids and gases contained in the rocks may therefore be subjected to gas pressure which, as is well known, may equal thousands of pounds to a square foot.

When a porous rock is inclosed between two impervious beds and the series is inclined, the natural arrangement of the three substances under consideration will be the same as just stated, but under certain conditions the petroleum and gas may be brought under hydrostatic pressure. To illustrate the requisite conditions for producing hydrostatic pressure, reference is made to the following diagram, which

represents a section of the earth's crust, say, 20 miles long and 1,000 feet deep, where the rocks have been gently folded. In the section two bodies of shale are shown, with an included layer of porous sandstone. If the sandstone is charged with petroleum and gas generated in the shales beneath, or possibly in its own mass, it is evident that these light substances will in part be flooded out by water entering where the layer comes to the surface in the eroded fold at the right. Under such conditions indications of petroleum and gas should occur at *a*, of the nature of springs of these substances or as a general exudation of heavy oil, since the freedom of escape would facilitate evaporation of the petroleum and its consequent concentration. The petroleum in the porous layer beneath the unbroken fold *b* would be above the water and subjected to a pressure equal to the height of the water in the porous layer above the base of the petroleum. An "oil pool" would therefore form beneath the fold *b*, which would be subject to the pressure of the water in the higher portion of the same bed. The outcrop of the porous bed, where it receives water, may be scores or hundreds of miles distant from the oil pool, and the height of the source of water supply scores or hundreds of feet above the

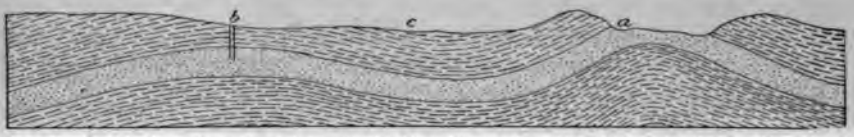

FIG. 1.—An ideal geological section illustrating the manner in which petroleum and natural gas accumulate in anticlines, and also the origin of hydraulic pressure on such "pools."

reservoir on which it presses. Gas generated from the petroleum in the oil pool beneath *b* would collect above it and form a gas pool, also under hydrostatic pressure. In computing the pressure exerted by water in cases like the one just cited, account must be taken of the density of the water, since, if highly saline, its weight will be materially increased. Under the conditions just assumed the oil and gas pools beneath *b* may enlarge until their bases extend laterally below the downward fold between *a* and *b*, when a limit would be reached, as an avenue of escape through the porous bed to the outcrop at *a* would then be furnished.

Under the conditions shown in fig. 1 a well drilled at *b* and reaching the porous layer would yield gas under pressure, which would escape without diminution of pressure until it was exhausted, providing the porous bed was sufficiently open textured to admit of the ready flow of water through it, otherwise the gas might escape more rapidly than the water could flow in, so as to maintain a constant pressure. After the gas had passed off the petroleum would rise in the well to a little above the level of *a*, depending on its specific gravity, and the gas well would be transformed into a "pumping" oil well.

Great variations in the general conditions illustrated above occur in

nature. The locality *a* may be much higher than the surface at *b*, in which case the gas first escaping would be followed by a flow of petroleum, and when that failed, water would follow and form an artesian well. Under the conditions shown in fig. 1, wells put down between *c* and *a*, with the hope of finding either petroleum or gas, must evidently result in failure.

Another source of pressure which may be brought to bear upon fluids and gases in a porous rock has been suggested, namely, the weight of the overlying rocks, but this hypothesis may evidently be discarded unless, after the rocks have been charged with water, petroleum, or gas, the weight of the superimposed strata causes compression, which diminishes the volume of the interstices in the porous bed. Such a change might evidently take place, but in general must be of such small amount in comparison with other causes of pressure on the contained fluids and gases that it need not be considered.

Geologists have found that it is not a scarcity of petroleum or gas that makes the occurrence of commercial quantities of the substance só valuable, but their concentration into what are termed "pools" or natural reservoirs. In this concentration the position in which the

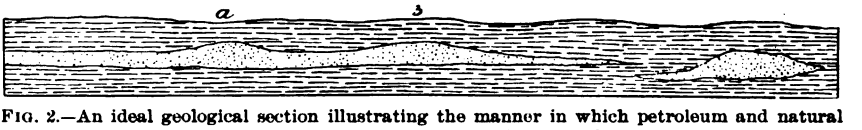

FIG. 2.—An ideal geological section illustrating the manner in which petroleum and natural gas may be concentrated in horizontal beds.

layers of rock in the earth's crust occur is in the highest degree important.

Stratified rocks, when first formed, were in nearly all cases essentially horizontal, but, owing to subsequent movements in the earth's crust, are now in many instances variously inclined, folded, and broken. In strictly horizontal beds it is evident that the conditions for concentrating the petroleum and gas they may contain are unfavorable. This, however, is not equivalent to saying that horizontally bedded rocks are of necessity destitute of oil and gas pools. For example, as in the section shown on fig. 2, the upper surface of a porous bed inclosed between two sheets of shale may be irregular, and the elevations in its upper surface might supply conditions similar to those furnished by an upward fold. In the diagram, oil and gas might accumulate at *a* and *b* under gas pressure and be of sufficient volume to yield valuable returns. Again, in horizontal, impervious beds there may occur irregular, porous, masses of rock—as sandy patches in shale or porous regions in limestone, for example—which would serve as reservoirs, and on becoming charged with petroleum and gas yield one or the other of these substances, according to the shape of the pool and the place where it chanced to be penetrated in boring. An illustration of such a possibility is shown to the right in fig. 2.

The influence of an inclination of the strata and of folds has already been briefly considered, but the importance of structure, to use a general term to designate the position in which the beds occur, is so important in the concentration of oil and gas into productive pools that it needs to be well understood by all who search for these substances.

In many regions the rocks are crumpled or corrugated into a series of up and down folds, termed, respectively, anticlines and synclines, as shown in fig. 1. Under the structural conditions there indicated it is evident that if petroleum and gas occur in the dotted stratum, assumed to be a porous sandstone between two thick beds of shale, and water is present, the petroleum will accumulate beneath the anticlines, and if evaporation occurs, as is the rule, gas will be generated, and both gas and hydraulic pressure will be present. These anticlinal folds, it will be remembered, have a length usually much greater than their width, and may measure scores of miles in their various dimensions. The longer axes of the folds may be horizontal or inclined, or pitch toward one end or the other. If the axes are horizontal it is evident that a well put down anywhere along the crest of a fold, as at *b* in the above cross section, should admit of a flow of gas followed by a rise of oil in the well, or its discharge, fountain-like, at the surface, according to the pressure. Should the anticlines have a pitch, however, one end of the fold being depressed or the other elevated, with reference to a horizontal plain, then it is manifest that the petroleum and gas would be concentrated near the upper portion of the pitching anticline and the area of the resulting "pool" consequently lessened. Other complexities of structure may be present, as, for example, where one series of folds crosses another series, thus producing conditions favoring the accumulation of several relatively small pools. Sometimes the rocks, instead of being folded into long, narrow anticlines, are elevated in certain regions so as to assume dome-like forms. A broad, low dome in a series of oil and gas charged beds, with the requisite succession of porous and impervious strata, would form the ideal conditions for the concentration of the substances named.

The conditions briefly explained above form the basis of the well-known "anticlinal theory" of the occurrence of oil and gas pools, so ably worked out by Prof. Edward Orton in Ohio and Prof. I. C. White in Pennsylvania and West Virginia.

A variation of the conditions just considered occurs when the strata are gently inclined over broad areas, and the rocks are bent along certain axes without being folded so as to form true anticlines, but produce flat terrace-like areas in a region of gently-inclined beds. Such "terraces" or "arrested anticlines" occur in Ohio and have been described by Professor Orton. For example, oil-bearing rocks about 2,500 feet thick enter the Macksburg oil field, dipping gently south-

east, at a rate of 20 to 30 feet to the mile, but they suddenly cease their descent and for about 3 miles there is no appreciable fall. The amount of territory included in the terrace appears to be 15 or 20 square miles. Beyond this the regular dip is resumed. It is difficult to understand how the petroleum and gas are retained in a "terrace" if it is really horizontal, but the conditions regulating the storage of these substances are so delicately adjusted that a difference of a very few feet in the height of the top of the porous layer may determine the success or failure of a well drilled to it. The difficulty of ascertaining the actual position of the surface of the porous layer when gently inclined is shown by the fact that a thickness of a thousand feet or more of overlying strata has frequently to be penetrated to reach the necessary rock. It is well known, however, that the nearly flat areas, as the drill shows them to be, in certain regions where the rocks are gently inclined in the same direction on each side, sometimes contain commercial quantities of liquid and gaseous hydrocarbons.

In the above consideration of the influence of structure and texture on the storage of petroleum and gas we have assumed that water is also present in the rocks. While this is the normal and practically universal condition, yet it may happen that water is absent from a porous layer containing the other two substances named. In the absence of water, petroleum would accumulate in the downward folds or would descend until arrested by an impervious stratum, and gas would occupy the remainder of the porous bed. An increase in the amount of gas would be accompanied by an increase in pressure. Under these scarcely to be expected conditions, a well penetrating a syncline would yield oil under gas pressure which might be great, while a well drilled in the course of an adjacent anticline would yield gas only, the oil not rising unless the relation of the well to the inclination of the porous layer was such that the oil itself could produce "hydraulic" pressure. In such a case the flow of petroleum would not be followed by water, and when the outflow ceased the well would still be filled with petroleum.

Certain modifications or limitations of the general principles above stated need to be kept in mind by persons searching for commercial supplies of petroleum and gas, lest valuable pools of exceptional character be overlooked.

One of the exceptional conditions referred to is the absence of a pervious stratum to act as a reservoir or receiver. For example, a bed of shale which is impervious to water may be of such a texture as to permit of the slow percolation of petroleum and the ready passage of gas. Should such an oil-charged shale occur in thick masses, as in the Cretaceous system in the great plateaus, without interbedded porous beds and not having an impervious cover, the gases generated would pass off, leaving heavy petroleum, which would descend to the bottom of the generating layer or until it was arrested by an impervi-

ous stratum. A well drilled in such a bed should furnish petroleum, but not under pressure. A small but long-continued yield by pumping might be expected, the petroleum slowly percolating into the well from the adjacent country rock in much the same way that an ordinary surface well is supplied with water. Under the conditions just postulated, but petroleum as well as water being absent, a well might yield a moderate but long-continued supply of gas.

Another consideration which may perhaps have economic importance is that the presence of petroleum, especially the heavier varieties, in a porous rock retards the passage of water. The outcrop of a porous bed, in which heavy oil has been produced by the evaporation of a lighter variety, might seal the pores of the rock and thus prevent the inflow of water, and therefore the cessation of the outflow of petroleum. These results might come about especially in a warm climate and modify the conditions under which petroleum and gas are usually stored. The formation of solid hydrocarbons in porous beds and in fissures is but a further step in this same direction. Bodies of petroleum-bearing sandstone or other rocks above the surface drainage of a region might, on account of the formation of viscous or solid hydrocarbons in their superficial portions, be made to yield heavy oil if penetrated by horizontal wells.

The opening of fissures communicating with the surface above an oil pool is considered fatal to it as a reservoir of commercial value, but if the oil is not under hydraulic pressure or if the pressure is not sufficient to cause it to overflow and be replaced by water, the petroleum may not rise in the fissure, or if it does rise not reach the surface, and on evaporating, seal the breach and renew the conditions favorable for natural storage. Fissures filled with solid hydrocarbons may therefore be considered as favorable indications of the presence of oil pools in their vicinity. While the conditions under which petroleum and its derivations occur in nature are simple and easily understood, the application of theory to practice is beset with difficulties and uncertainties. The information that is wanted is the texture of the rocks, the order of their occurrence, and their structure at a depth of several hundred or perhaps several thousand feet below the surface, and this, too, when the surface is usually covered with vegetation and soil, alluvial deposits, and possibly a thick sheet of glacial drift. While the geologist is better able than anyone else to judge of the conditions to be expected within the earth's crust, it must be confessed that the only practicable way to secure the desired facts in untried regions, is in many instances, to put down test wells at what seem the most favorable localities. One important duty of the geologist is to discourage ventures in regions where the rocks are so greatly disturbed and broken that gas or water-tight reservoirs can not exist, or when other conditions such as the metamorphism, preclude the probability of success. The conditions which have led to the

accumulation and storage of petroleum and gas are in general the reverse of those which lead to the accumulation of water in artesian basins. The most promising localities in the search for relatively light hydrocarbon, are in upward folds or anticlines and the most favorable localities for storing water in the rocks under pressure are in downward folds or synclines. This difference in the conditions leading to accumulation of oil and water, as an effort has been made above to explain, is due to the differences in the specific gravities (or weight of equal volumes) of the substances named. If a fluid heavier than water should be present in the rocks, the other conditions considered being the same, the water would be forced upward and would accumulate in anticlines, and the most favorable localities for searching for artesian water would be in the upward folds, instead of as now, in the downward folds.

APPLICATION.

In attempting to apply the principles just considered in Idaho and Oregon, it is evident that the search for petroleum should be confined to regions where the rocks have been but moderately disturbed, and in such regions drill holes should be put down in the crests of anticlinal folds. The downward folds or synclines should be avoided, as water is everywhere present in the rocks and all the downward folds may be expected to be filled with it. Experience in southern Idaho has fully sustained these deductions, and much time and expense might have been saved if they had been given proper consideration when the search for petroleum began. All of the drill holes thus far put down with the hope of obtaining petroleum are located in broad synclinal basins, and in nearly all instances have resulted in obtaining a surface flow of water. Even after several artesian wells had been obtained, the drilling of holes for petroleum was continued in the same basin, as in Snake River Valley, between Guffey and Weiser, and uniformly with the same result. Although there has been a total failure to obtain petroleum, what in the end will prove to be a much more valuable result, so far as the development of the region is concerned, has been secured, namely, the demonstration of the value of the Lewis artesian basin.

While the region crossed by Snake River in western Idaho and the adjacent portion of Oregon, in the vicinity of Owyhee, Vale, and Ontario, is a broad syncline, nearly flat in its central portion, it does not follow that the entire region is a single great fold. There may be secondary wrinkles, and beneath the small upward folds, if such are present, petroleum and gas might occur, and be under the pressure of the water in the broader and in general trough-shaped depression.

The only locality in the Snake River Valley in western Idaho, so far as I can judge from the explorations I was enabled to make, at which one would be justified in drilling for the purpose of prospecting for petroleum, is the southern part of Canyon County, in the vicinity

of Pickles Butte. I was not able to visit the region referred to, but views of it obtained from a distance suggested that the rocks there rise into a small anticline, the longer axis of which trends about northwest and northeast. A careful study of the region referred to should show whether an anticline is present or not, and if discovered a drill hole put down to a depth of 1,000 or 1,200 feet would furnish a crucial test as to the presence of petroleum or gas. So far as can be judged, the Payette formation, which, together with sheets of basalt, underlies the Snake River Plains, is notably free of organic matter, and the chances seem to be that even if anticlines or other conditions favoring the storage of petroleum or gas are present, but little hope of obtaining commercial quantities of these substances can reasonably be entertained.

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PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 217.]

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SEPTEMBER, 1903.

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Bulletin No. 218 Series A, Economic Geology, 26

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

THE COAL RESOURCES OF THE YUKON, ALASKA

BY

ARTHUR J. COLLIER

WASHINGTON
GOVERNMENT PRINTING OFFICE
1903

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., June 13, 1903.

SIR: I have the honor to submit herewith a report entitled "The Coal Resources of the Yukon," by Mr. Arthur J. Collier, and to recommend its publication as a bulletin. This report deals entirely with the economic results of Mr. Collier's investigations during the last field season. His studies of the Yukon section developed some very important stratigraphic results regarding the Mesozoic and Tertiary succession, but the limited time made it impossible for him to solve the many interesting problems that arose in the course of the work. It has therefore seemed best to include in this report only the barest outline sketch of the geology, the more complete discussion of the stratigraphy being deferred until the results of further studies, already begun, shall be available.

Very respectfully,

ALFRED H. BROOKS,
Geologist in Charge of Geologic Work in Alaska.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

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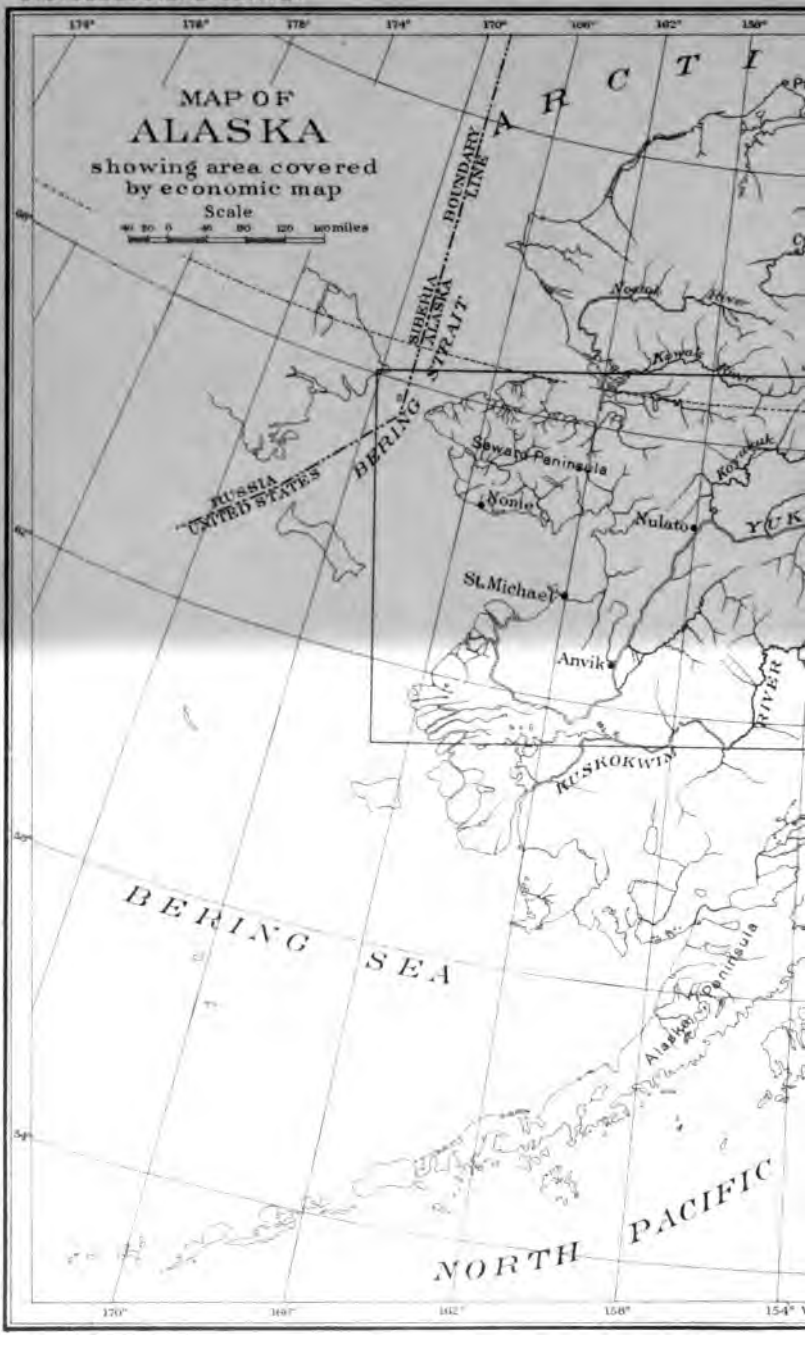

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THE COAL RESOURCES OF THE YUKON, ALASKA.

By Arthur J. Collier.

INTRODUCTION.

During the summer of 1902 the writer was detailed to make an examination of the coal deposits along Yukon River, in Alaska. His instructions were, in part, as follows:

> You are hereby assigned to the work of making a geologic reconnaissance of the Yukon River from the international boundary to the delta.
>
> The most important economic problem is the investigation of the coal deposits. You are expected to make a careful study of all the coal seams which have been exploited adjacent to your route of travel. It is important to obtain paleontologic data in regard to the age of the coal. You are also expected to visit such placer deposits as may be easily accessible from the river. You will devote special attention to the problems of stratigraphy of Yukon River section, and are expected to visit the various localities at which fossils have been found and make extensive collections.

In compliance with these instructions, a small party, consisting of Sidney Paige and Charles Kronholm, camp hands, and the writer, geologist in charge, left Seattle early in June and went by steamer and railway to Dawson, Yukon Territory. There a canoe and a rowboat were purchased.

The party left Dawson June 15, and the following three months were spent in a study of the geology and coal resources along the Yukon for 1,200 miles. The greater part of the investigation was confined to the actual river bank, yet the work was extended away from the stream when time and circumstances would permit. The work was continued until the close of the season, about the middle of September, which found the party at Pimute, a small native settlement near the head of the delta. At this point the party embarked, September 17, on the river steamer *John J. Healy* for St. Michael, and thence returned to Seattle.

In the prosecution of the work the writer received much assistance from residents of Alaska along the route. The investigation was greatly expedited by many favors received from agents and officials of the Northern Commercial Company. Much valuable information

was also obtained from E. J. Chamberlain, United States deputy mineral surveyor at Eagle, and from W. E. Williams, a mining engineer, who has had the management of a number of Yukon coal mines.

Nearly all the known coal beds accessible from the Yukon were examined, though the limited time in some cases made it necessary to do the work very hastily. Collections of fossils were made from 53 localities, many of which were entirely new. In numerous instances these collections were sufficient to determine the age of the coal beds, yet some remain in doubt. These studies and collections have thrown much light on some of the vexed problems of Yukon stratigraphy, but important questions still remain to be settled by further investigations. The paleontologic and paleobotanic collections have been studied by Drs. T. W. Stanton and F. H. Knowlton, of the Survey, and by Mr. Charles Schuchert, of the United States National Museum. Though the results of these studies are of far-reaching importance, their publication is deferred until further paleontologic and stratigraphic field studies have been made and more definite evidence for correlations has been secured.

The study of the structural and stratigraphic geology of the terranes exposed along the river was rendered more difficult by the lack of an accurate base map, for up to the present time no complete instrumental survey of the Yukon has been made. Sketches of a portion of the stream were made by Dall and other members of the Western Union Telegraph survey in 1864-65 and in 1866. Captain Raymond[a] made latitude determinations at and below Fort Yukon in 1869. Lieut. Frederick Schwatka[b] made a military reconnaissance of the Yukon in 1883, and a topographic sketch of the river from its source to its mouth was made at this time by Charles Homan, topographer of the party. The position of the river at the international boundary, at Fort Yukon, and at Nulato has been determined by astronomic observations made by parties of the Coast Survey, and the positions of Fort Hamlin, Rampart, Tanana, and the mouth of the Koyukuk have been determined by parties of the United States Geological Survey, who have also surveyed some short stretches of the river. For the details of the stream between these points all map makers have ultimately depended on Lieutenant Schwatka's map as modified by supplementary sketches made by various travelers and explorers. During the last season Mr. Sidney Paige, under the writer's direction, carried a canoe traverse from Eagle, near the international boundary, to Pimute. This sketch survey was carried on by estimated distances and compass azimuths. The map of the Yukon submitted with this report (Pl. II) is taken from a map of Alaska

[a] Raymond, Charles P., Reconnaissance of the Yukon River: Narratives of Explorations in Alaska. Washington, D. C., 1900, p. 19 et seq.

[b] Schwatka, Frederick, Military reconnaissance in Alaska in 1883: Senate Ex. Doc. No. 2, 48th Congress, 2d session.

compiled in 1902 and 1903 by E. C. Barnard,[a] of the United States Geological Survey, but has some minor corrections and additions from data obtained by Mr. Paige and the writer.

References to coal outcrops are not uncommon in some of the earlier writings on travel and exploration in Alaska, but up to 1895 no systematic attempt had been made to gather this information together. In that year Dall visited many of the localities where coal occurs in the Pacific coast province of Alaska, and in the report[b] based on this investigation included a summary of all the available data in regard to the coal in the interior. In the following year Spurr visited a number of the coal prospects on the Yukon and embodied descriptions of them in his report.[c] During the years from 1898 to 1902 information in regard to coal in Alaska was gathered by the various parties of the United States Geological Survey working in the district, and also by members of the Canadian survey in the adjacent parts of the Yukon Territory. Brooks summarized all this information in a report[d] which also contained a provisional table of correlation of the coal-bearing horizons.

It will be the purpose of the following report to summarize the economic results of the present investigation of the coals of the Yukon and to consider briefly their commercial bearing, while the discussion of the more purely scientific problems will be left for another report. It is hoped that this report, in spite of its incompleteness, may aid the development of coal mining on the Yukon, which must be of importance in connection with the exploitation of the other resources of this northern region.

GEOGRAPHY.

The Yukon is the largest river of Alaska and one of the largest on the continent. It has a length, from its mouth to the source of its longest tributary, of about 2,400 miles, of which 1,300[e] miles are in Alaska (see map, Pl. I). It empties into Bering Sea, and its headwaters lie far to the southeast, in British Columbia. Its drainage basin includes a large, irregularly shaped area, roughly blocked out by the Rocky Mountain system on the north and east and by ranges of the Pacific[f] mountain system on the south and west. To the south-

[a] Brooks, Alfred H., The geography of Alaska: Prof. Paper U. S. Geol. Survey No. — (not yet published).

[b] Dall, William H., Report on coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 769–908.

[c] Spurr, J. E., Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 101–391.

[d] Brooks, Alfred H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 515–571.

[e] The U. S. Coast Survey (*see* Route Map of Yukon River, Chart No. 3098) estimates the distance by river from St. Michael to Dawson at 1,313 miles. River pilots and steamboat men estimate the same distance at above 1,900 miles. The actual distance probably falls between these estimates.

[f] Brooks, Alfred H., Geography of Alaska: Prof. Paper U. S. Geol. Survey No. —.

east the basin is not outlined by any mountain chain, and the tributaries of the Yukon interlock irregularly with those of the Liard, which is confluent to the Mackenzie, and with the Stikine, flowing into the Pacific. The chief of the Yukon tributaries are the Koyukuk, the Tanana, the Porcupine, the White, the Pelly, and the Lewes. The last two rivers named unite to form the Yukon proper. The general trend of the upper drainage channels of the basin is to the north and northwest to the point where the Yukon touches the Arctic Circle; at this point the river makes a right-angled bend to the southwest and continues to hold this general course to the head of the delta.

The catchment basin of the Yukon, which includes about one-quarter of the area of Alaska, lies for the most part in what has been called the Central[a] Plateau region—that great dissected upland area lying between the Rocky Mountain system on one hand and the Pacific mountain system on the other. In its upper course the Yukon Valley is incised to a depth varying from 2,000 to 3,000 feet, and has a width of from 2 to 3 miles. Near the international boundary the valley contracts to a width ranging from one-half mile to a mile, and 150 miles below it broadens out again and merges into that extensive lowland known as the Yukon Flats. Through this lowland the Yukon finds its way by many intricate channels, which in places spread out to a width of 10 or even 15 miles. Below the flats the river flows through a constricted part of its valley, known as the Ramparts, from which it emerges near the mouth of the Tanana. For about 600 miles below the Ramparts the valley is broad, and the river meanders over a wide flood plain. At the head of the delta the Yukon separates into a number of widely diverging distributaries.

Since the Yukon is one of the great rivers of the world and is navigable by steamer for over 2,000 miles, and in both winter and summer is the great natural highway of travel through the interior of Alaska, development has been more rapid and exploration has been made more complete along it than in most other parts of Alaska.

By the middle of the nineteenth century the Russian and Hudson Bay fur traders had already established themselves on the Yukon, and up to the time of discovery of gold, in the early eighties, this trade was the only thing that brought white men into the country. After the discovery of gold many prospectors made their way into the region, and at the time of the finding of the Klondike placers, in 1896, mining was carried on at several points on and near the Yukon, and camps were established at Rampart and Circle in Alaska and at Fortymile on the Canadian side. At that time one or two small steamers brought all the supplies from St. Michael for the mining camps and trading posts. The influx of population brought about by the Klondike discoveries led to a phenomenal development of the transporta-

[a] Brooks, Alfred H., Geography of Alaska: Prof. Paper U. S. Geol. Survey No. —.

A. CHARACTERISTIC VIEW OF THE BANKS OF THE YUKON, SHOWING FUEL RESOURCES.

B. EAGLE, ON YUKON RIVER. SEAT OF U. S. DISTRICT COURT, U. S. CUSTOM-HOUSE, AND FORT EGBERT U. S. MILITARY POST.

tion facilities, so that in 1898 and 1899 there were nearly 100 steamers on the Yukon and its tributaries. At present probably 25 steamers furnish all the transportation required. At this time the principal Alaskan settlements on the river are Koserefski, Anvik, and Nulato, Indian villages, and Tanana, Rampart, Circle, and Eagle, mining towns. United States military posts are maintained at Tanana and Eagle, known as Fort Gibbon and Fort Egbert, respectively. Pls. III, *B* and VI, *B* show views of two characteristic towns—Eagle, a settlement of white men, and Nulato, an Indian village.

The city of Dawson, in Canadian territory, is the most important settlement on the Yukon, and the traffic of the river consists largely of freight to this point. The White Pass and Yukon Railroad competes with the river steamers for the Dawson freight. All perishable goods for Dawson and points below go by this route. The greater part of the freight, however, still comes by the longer and slower river route. The steamers plying on the Yukon up to the present time have, in the majority of cases, depended for fuel on wood cut and piled on the river banks. Pl. IV shows the character of the steamers and the nature of the fuel used. In the earlier days of steamboat navigation it was customary for steamboats to tie up to the river bank while their crews cut wood and carried it on board. A few of the river steamers now burn coal altogether; others burn both coal and wood. Up to the present time wood has been easily obtained near the river banks, but since the timber of the Yukon is small and of slow growth, the supply is limited, and woodcutters are obliged to bring it a greater distance every year. Pl. III, *A* shows the general character of the timber which has afforded fuel for river steamers.

Coal mines have been operated at a number of points, the oldest being the Drew mine, first known as the Miller mine, 25 miles above Rampart. Mines in operation during 1902 are located at Five Finger Rapids and Cliff Creek, both in Canadian territory, and at several points near Nulato, in American territory.

This coal has been burned with varying success by Yukon River steamers. The results obtained depend on a number of factors, among them being the character of the coal, the appliances for burning coal on the steamers, and the experience of the firemen. It is planned to use petroleum from the California fields as fuel on some of the steamers of the Northern Commercial Company during the season of 1903.

SKETCH OF GEOLOGY.[a]

The first notes on the geology of the basin of the Yukon were those made by Dall,[b] who ascended the river to Fort Yukon in 1866. Subsequent travelers occasionally referred to the geology and

[a] This sketch of the geology was prepared with the collaboration of Mr. Alfred H. Brooks.

[b] Dall, W. H., Am. Jour. Sci., 2d ser., vol. 45, 1868, pp. 97-98; also Bull. U. S. Geol. Survey No. 84, p. 247.

mineral resources of the region, but no investigations were made by a geologist until 1888, when Dawson[a] visited the upper basin. In the following year McConnell[b] extended the observations of Dawson as far as Fort Yukon by his trip down the Porcupine. Further information was obtained by Russell[c] in 1890, who ascended the full length of Yukon and Lewes rivers, and by Hayes,[d] who entered the basin by way of the Hootalinqua and left it by the White River Valley, in 1891. Somewhat more systematic work was begun by a trip made by Spurr, Goodrich, and Schrader,[e] who in 1896 made a rapid reconnaissance of the river from Chilkoot Pass to Nulato. The result of their work led to the publication of the first geologic map of a section of the Yukon, together with suggestions for the correlation of the work of all the previous investigators of the region. Spurr's report contains the first attempt at a determination of the stratigraphic succession in the basin of the Yukon, and in the accompanying table his nomenclature has been accepted as far as possible. In 1898 Spurr[f] made a reconnaissance in southwestern Alaska, and in the map accompanying his report embodied the results of his previous investigations on the lower Yukon. In the same year Brooks[g] made a reconnaissance of White and Tanana rivers. In 1899 Schrader[h] studied the geology of Chandlar and Koyukuk rivers, and thus extended the knowledge of the stratigraphy from the Yukon northward, while Brooks[i] made a reconnaissance which extended to the Yukon at Eagle. In 1901 Mendenhall[j] made a trip from Fort Hamlin to Kotzebue Sound, and the result of his work throws further light on the geology north of the Yukon. In 1902 Brooks[k] briefly summarized all of the available information regarding the stratigraphy of the Mesozoic and Tertiary terranes of the Yukon. During the last few years the Canadian geologists have been actively at work

[a] Dawson, George M., Report on an exploration in the Yukon district, N. W. T., and adjacent northern portion of British Columbia: Geol. and Nat. Hist. Surv. Canada, Ann. Rept., new series, vol. 3, pp. 1B-277B.

[b] McConnell, R. G., Report on an exploration in the Yukon and Mackenzie river basins, N. W. T.; Geol. and Nat. Hist. Surv. Canada, new series, vol. 4, 1888-89, pp. 134D-145D.

[c] Russell, I. C., Notes on the surface geology of Alaska: Bull. Geol. Soc. America, vol. 1, 1889, pp. 99-162.

[d] Hayes, C. Willard, An expedition through the Yukon district: Nat. Geog. Mag., vol. 4, 1892, pp. 117-159.

[e] Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 87-392.

[f] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1899, pp. 31-264 and maps 4-14.

[g] Brooks, Alfred H., A reconnaissance in the Tanana and White river basins, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1899, pp. 425-494.

[h] Schrader, F. C., Preliminary report on a reconnaissance along the Chandlar and Koyukuk rivers, Alaska, in 1899: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 441-486.

[i] Brooks, Alfred H., A reconnaissance from Pyramid Harbor to Eagle City, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 331-391.

[j] Mendenhall, W. C., Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska: Prof. Paper U. S. Geol. Survey No. 10, 1902.

[k] Brooks, Alfred H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 515-571.

A. STEAMER LOADING WOOD ON UPPER YUKON.

B. WOOD-BURNING STEAMER ON YUKON, BELOW EAGLE.

studying the stratigraphy and mineral resources of the Yukon Territory. Notable among these is R. G. McConnell.[a]

The following table is intended to present in a concise form the present state of knowledge of the stratigraphic column of the Yukon below the international boundary. The table is based on the results of all previous investigations of the region, modified by the field studies of the writer and the studies by various paleontologists of the collections made. Though a number of horizons were found which up to the time of the present investigation were unknown in the region, it has been thought best not to introduce any new formation names in this publication nor to attempt any far-reaching correlations. The formation names already current in geologic literature have been retained as far as they were borne out by the studies of the last season.

Provisional tabular statement of Yukon stratigraphy.

Age.	Formation name.	Contact relations.	Lithologic character.
Recent	Alluvium		Flood-plain deposits.
Pleistocene?	Yukon silts	Unconformity	Fresh-water silts, sands, and gravels.
Post-Eocene Tertiary.	Twelvemile beds. Palisade conglomerate.	(?)	Sands, clays, and gravels.
Upper Eocene	Kenai series	(?)	Fresh-water sandstones, shales, and conglomerates.
Upper Cretaceous.		Conformity ?	Fresh-water and marine sandstones, shales, arkoses, and conglomerates.
Lower Cretaceous.		(?)	Fresh-water calcareous sandstones.
Do		(?)	Marine black, slaty shales, and thin-bedded limestones.
Permian		Unconformity	Marine, massive, white limestones, heavy conglomerates, and gray shales.
Lower Carboniferous.		do	Marine black slates and thin-bedded limestones.
Devonian?	Rampart series	(?)	Volcanic material, interbedded with limestone, slate, etc.
Older than Devonian.	Fortymile series	Unconformity	Schists and interbedded limestones.
Do	Birch Creek series.	Conformity	Quartzites and schists.
Undetermined	Pelly gneisses	Unconformity	Gneissoid and schistose granites.

The section along the Yukon between the international boundary and the delta includes terranes widely separated in the geologic column,

[a] McConnell, R. G., Yukon district; Summary report of the Geological Survey Dept. for the year 1900, Ottawa, 1901, pp. 37-52.

and in some instances having very intricate stratigraphic relations This succession contains some horizons which have been fairly wel established by stratigraphic and paleontologic studies, but also other whose position in the geologic column is very much in doubt.

An examination of the table will show that the oldest rocks in th region are of a gneissoid character, and for these the name Pell gneisses has been suggested by Brooks and accepted by McCon nell. These Pelly gneisses are an intricate series of crystallin rocks whose genesis is doubtful. A part of the rocks grouped wit these gneisses are altered intrusives, and closer investigation wi undoubtedly show that some of them are younger than the sediment they are supposed to underlie. One belt of the Pelly gneisses occur in the Fortymile, along the axis of an anticlinal uplift, as describe by Spurr, and another was seen by the writer between the Melozi[a] an the Yukon. The gneissic series everywhere shows evidence of havin been subjected to profound metamorphism. The Pelly gneisses ar succeeded unconformably by a great thickness of quartz-schists an quartzites, called by Spurr the Birch Creek series. These pass abov into a white crystalline limestone formation named the Fortymil series by Spurr. Both of these series find extensive development i the upper part of the region under discussion. The Rampart series characterized by rocks of greenish color and preponderance of volcani matarial, overlies these unconformably, and is probably of Devonia age. The two older formations are more altered than the younger but all have undergone considerable deformation and igneous intru sions are abundant.

Near Seventymile River the writer found a series of black slate and shales interbedded with thin bands of semicrystalline limestones in which Lower Carboniferous fossils were found. These beds ar intensely crumpled.

The next succeeding horizon is the so-called Tahkandit series o Spurr, which is made up of conglomerates, sandstones, and shale overlain by a heavy bed of semicrystalline limestones, which ha yielded abundant fossils near Nation River. These fossils ar regarded as Permian. Spurr's Tahkandit group is not included i the accompanying table, because he gave to this name a broade significance than can be accepted in the present investigation. Thi sandstone, conglomerate, and limestone series is closely folded an much metamorphosed.

Below Nation River the Permian beds are overlain by a great thick ness of black, slaty shale containing some intercalated beds of lime stones and calcareous sandstones. In these beds the writer foun fossils which were determined by Dr. Stanton to be *Aucellæ* of Lowe

[a] This river is known in Alaska as the Melozikakat. Melozi is here used in conformity with t decision of U. S. Board on Geographic Names, "kakat" being merely a native term for river

Cretaceous age. These beds would belong with Spurr's Mission Creek group. This name has, however, not been retained in the present stratigraphic classification, because it was found that under it Spurr had included beds as widely separated in the geologic column as the Eocene and Carboniferous. The Lower Cretaceous beds outcrop for about 80 miles along the Yukon. The beds are rather closely folded and somewhat faulted.

On the lower portion of the river, near Nulato, some fresh-water cycad-bearing beds have been found which are also probably assignable to the Lower Cretaceous. These beds are chiefly calcareous sandstones, with some shales. They differ from the Lower Cretaceous of the upper river in that they are apparently of fresh-water origin. Their relation to the Upper Cretaceous which outcrops in the vicinity has not been determined.

The Upper Cretaceous is represented near Nulato by sandstones, conglomerates, and dark-colored shales, which outcrop along the river at intervals for about 100 miles. These have in part yielded a marine invertebrate fauna of Upper Cretaceous age, as determined by Stanton. Fossil plants were found in the same general horizon and were assigned by Dr. Knowlton to the Upper Cretaceous. It is evident, therefore, that these beds include both marine and fresh-water deposits. The fresh-water beds carry coals of commercial importance. The Cretaceous beds have undergone considerable deformation, but are not metamorphosed, and, in fact, are only slightly indurated.

The succeeding horizon is made up chiefly of sandstone and conglomerate, with some shale. It is called the Kenai series, and is of Upper Eocene age. These beds usually carry abundant plant remains, which show them to be of fresh-water origin. The Kenai series has been named from its typical occurrence on Kenai Peninsula and has been identified in various other parts of Alaska. It occurs in isolated areas on the Yukon near the boundary and near Rampart, and is more extensively developed near Nulato. On the upper river it unconformably overlies various horizons below the Upper Cretaceous, but near Nulato its relation to the Upper Cretaceous seems to be one of conformity. The Kenai beds are, as a rule, little disturbed, but in some localities they have suffered considerable deformation. The Kenai is the great coal-bearing horizon of Alaska. Its coals are usually characterized by the presence of fossil resin, or amber.

Tertiary horizons younger than the Kenai have as yet been only locally differentiated in the province, but the evidence points to considerable development of Miocene or Pliocene beds. Spurr[a] described some lignite-bearing sands and clays on Mission Creek near the Yukon, under the name "Twelvemile beds," and some cross-bedded gravels

[a] Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 197 and 199.

and sands at the Palisades, which he called the "Palisade conglomerate." These two occurrences he regards as probably of Miocene or Pliocene age.

Fine silt deposits are widely distributed along the Yukon and many of its tributaries. These occur as terraces along the valley walls, and the bluffs formed by the undercutting by the river of these terraces are conspicuous features of the landscape of the Yukon. Within the limit of glaciation these silts are found mantling the till. The silt has a thickness of from 50 to 200 feet or more.

These beds have been described by various writers, but more especially by Spurr,[a] who named them the Yukon silts. Typically, the terrane is made of buff-colored silts, often resting on basal gravel beds, which may or may not be of the same age. The Yukon silts are for the most part of Pleistocene age,[b] as is shown by both vertebrate and invertebrate fossils. The silts are found resting unconformably on all of the older formations, except possibly some gravels which may be of Pliocene and Miocene age. They are separated by an unconformity from the Kenai series. The silts, though entirely unconsolidated, are in places thrown up into broad, open folds, and at one locality faulting was observed. This deformation usually makes it easy to separate them from the recent alluvium deposits, but in some cases the recent and older silts are entirely conformable and can not be differentiated. It is probable that more detailed studies will show that a part of what is now regarded as Yukon silt will be found to belong to one of the later Tertiary horizons. Some impure lignite beds have been found in these silts.

The youngest water-laid deposits here to be considered are the alluviums of the river and stream valleys. These are often very similar to the Pleistocene silts, but are usually of a darker color. They are found in the flood plains of the river and form extensive deposits in the broad lowland known as the Yukon Flats. In places where the Yukon silts have been warped down below the present level of the river the alluviums rest conformably upon them, but usually the relation is one of unconformity.

Some areas of volcanic rocks are found on the Yukon below the mouth of the Koyukuk. These are lavas and tuffs of andesitic and basaltic nature. Basaltic or andesitic dikes are not uncommon in the pre-Miocene sediments. Spurr[c] has discussed similar occurrences in the Yukon Basin at some length, and suggested the early Miocene or late Pliocene age of these extrusives. Local deposits of lignite,

[a] Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 200-221.

[b] Spurr, op. cit., p. 199; Brooks, A reconnaissance in the Tanana and White River basins: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1899, p. 475.

[c] Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 242-250.

usually of poor quality and of no economic value, are common in these tuffs. At a point about 50 miles above Kaltag an attempt has been made to exploit them.

THE COAL.

GEOGRAPHIC DISTRIBUTION AND CHARACTER.

Coal of commercial importance is found in two different geologic horizons along the Yukon, namely, in the Upper Cretaceous and in the Kenai series. The Yukon silts contain some impure lignites, but they have no value. It will be shown below that coal seams which have been opened up near Nation River may be of Permian age, but these appear to be of little future importance. From the standpoint of the coal miner, therefore, all of the Yukon coal can be said to be of either Cretaceous or Tertiary age. On the map (Pl. II) the areal distribution of the coal-bearing series along the Yukon is given as far as it has been determined, but it has not been found feasible, from the data at hand, to differentiate the Cretaceous coals from those of Tertiary age. The map also shows the areas of non coal-bearing rocks as far as known. These are divided into four classes, the first comprising the metamorphosed sediments, the second the Yukon silts, and the third the recent alluvium, while the areas occupied by igneous rocks comprise a fourth class. The coal prospector should confine his search for merchantable coals to the areas occupied by coal-bearing rocks.

It has been noted that the Kenai series occurs in small, isolated areas along the Yukon above the mouth of the Tanana. These in some cases represent remnants of larger areas, which are now infolded with the older beds; in other cases they probably represent separate basins of deposition. Outside the region under consideration the Kenai series, occurring in small basins, has been found to be one of the most widely distributed formations in Alaska. These coal-bearing beds rest unconformably on nearly all the older formations that have been identified in Alaska, and their conglomerates contain pebbles derived from them. The coal beds are not confined to any one definite horizon in the Kenai. In some instances they are known to be near the bottom of the formation; in others they lie near the top. This irregularity is what may reasonably be expected, for if the Kenai sandstones were deposited in fresh-water basins that were usually not connected, the formation of coal beds would probably not occur in all the basins at the same time, nor would the coal beds hold the same position in the series in all cases. All the coals examined in the Kenai basins along the Yukon above Tanana are lignites, or at least are lignitic in character.

The Upper Cretaceous, which is the lower coal-bearing horizon, is extensively developed on the lower Yukon. It outcrops along the

north bank for about 200 miles below the mouth of Melozi River, being interrupted only here and there by silt deposits or by narrow belts of extrusive rocks. It is intimately associated with Kenai beds in this region. This area probably extends westward to Norton Sound, where coal-bearing beds have been found.

In the Upper Cretaceous coal occurs in the lowest as well as the highest beds, as indicated by the fossil plants. The Upper Cretaceous coals have higher fuel ratios than the Eocene coals and are of somewhat better quality.

DESCRIPTIONS OF LOCALITIES.

INTRODUCTION.

The region under discussion falls naturally into an upper division, extending along the river from the boundary to the Yukon Flats; a middle division, extending from the lower end of the flats to Melozi River, and a lower division, extending from the Melozi to the mouth of the Yukon. These divisions can be conveniently described under the headings Circle province, Rampart province, and Nulato province.

Under Circle province will be considered all the known coal-bearing areas along the Yukon between Circle and Fortymile. With one exception these coals resemble one another both in character and in mode of occurrence. This province includes the coal beds at Cliff Creek and Coal Creek, in Canadian territory near Fortymile, and for the sake of comparison a brief note regarding these Canadian localities will here be included.

The Rampart province will be made to embrace the scattered coal-bearing areas between the Yukon Flats and the Melozi, including the lignite beds of the Yukon silt formation which occur at the Palisades. The coals of this province resemble those of the Circle province.

The coal deposits along the Yukon from Melozi River to the delta will be discussed under the caption Nulato province. These coals have common characteristics in composition and mode of occurrence, differing from those of the Circle and Rampart provinces.

Some compiled information showing the extent of the coal-bearing formation within the Yukon Basin in regions not examined by the writer will be presented in connection with the descriptions of contiguous divisions of Yukon River.

CIRCLE PROVINCE.

The greater part of this province is in Alaska, though the only coal mine at present in operation is within Canadian territory. From the international boundary to Circle, a distance of about 150 miles, the Yukon flows with a swift current, and receives several tributaries of

considerable size. Fortymile River, Seventymile River, and Charlie River, tributaries entering from the south, are navigable for small boats and canoes. Sheep Creek (Tatandu River), Nation River (Tahkandit River), and Charlie Creek (Kandik River) are the larger tributaries from the north.

The two important towns in the province are Circle, the supply point for the Birch Creek mines, and Eagle, at which place Fort Egbert, a United States military post, the United States custom-house, and the United States district court are located. Eagle is also the supply point for a number of placer mines located on the tributaries of Mission Creek and Seventymile River. It is also the Yukon terminus of the Valdes mail route. A view of the town is given in Pl. III, *B*. A number of small settlements, depending for their support on small placer mining camps, are scattered along the river between these points. Dawson, in Canadian territory, is about 100 miles up the river from Eagle; Fort Yukon, an important fur-trading post, and the point of departure for the Koyukuk winter trail, is 80 miles below Circle, at the mouth of Porcupine River.

Below Circle the Yukon flows for 300 miles through the Yukon Flats. Here the river spreads out in many channels and navigation is difficult. A characteristic view in the flats is given in Pl. III, *A*.

An examination of the map (Pl. II) will show that a belt of coal-bearing beds stretches from Klondike River northwestward nearly to the Yukon. This belt seems to be extended to the northwest by several isolated areas, which probably at one time formed a continuous belt. These Kenai terranes—for these beds all belong to that horizon—carry workable coal beds, which have been exploited at several localities.

Coal beds have been opened, or partially opened, by prospectors on two "Coal" creeks in Canadian territory and on American Creek, Wolf Creek, and Washington Creek in American territory. Coal is known to occur, but has not been opened to any extent, on Coal Creek, a small tributary of the Yukon 60 miles above Circle; on Bonanza Creek, a tributary of Charlie River; and on a tributary of Seventymile River known as Washington Creek. The more important of these localities were visited by the writer and will be described in detail. Coal has also been reported from the upper Fortymile region, from Seventymile, and from the Porcupine, but the information is too vague to make it worthy of inclusion in this report.

Coal in Canadian territory.—A coal seam was opened up near Five Finger Rapids on Lewes River many years ago. This seam has been recently developed under the name Five Finger mine,[a] and is now supplying the Dawson market. As this coal is used in competition with the Yukon coals, it seems best to include some notes on it, though

[a] Brooks, A. H., Coal resources of Alaska: Twenty-second Ann. Rept. U.S. Geol. Survey, pt. 3, 1902, p. 559.

the locality was not visited by the writer. This mine is about 200 miles above Dawson, on the north bank of the Lewes. Cretaceous fossils have been found in the vicinity, though their relation to the coal formation is not known to have been definitely determined. The coal seam mined is reported to be slightly less than 2 feet in thickness. The following analysis was made from a sample taken by the writer from a large pile of this coal on the electric light company's dock at Dawson:

Analysis of coal (sample No. 311) from Five Finger mine.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	3.58
Volatile combustible matter	41.05
Fixed carbon	43.11
Ash	12.26
	100.00
Sulphur	.38
Fuel ratio	1.05

The sample of coal taken shows many check seams containing small, light, knife-edge veinlets, both parallel to the bedding and across it, and these probably account for the high percentage of ash. Coal from this mine is burned on river steamers, and a considerable amount is shipped to the Dawson market, where it seems to be preferred to Cliff Creek coal.

Coal of anthracite nature is reported from the vicinity of White Horse Rapids,[a] and lignite is found on Nordenskiold River,[b] near the railway.

The most important coal mine on the Yukon within the Circle province is at Cliff Creek, which enters the Yukon from the north, about 9 miles below the town of Fortymile and 30 miles above the international boundary.

The following is quoted from the Canadian geological survey reports[c] regarding the coal basin:

Lignite-bearing beds outcrop on Klondike River, 6 miles below Flat Creek, and extend in a north-northwesterly direction in a long, narrow basin or series of basins to Cliff Creek, a distance of 60 miles, and probably for some miles beyond. They follow in a general way the course of the Yukon Valley, from which they are separated by a narrow strip of the older rocks. Wide valleys are cut across them by all the streams entering this portion of the Yukon from the northeast, but owing to their soft character exposures are infrequent. In their normal condition the beds consist of soft, slightly coherent sandstones and conglomerates, alternating with light and dark-colored clays and shales. In places where the beds have been strongly folded the clays and sands are altered into sandstones and shales. The age of the lignite beds is uncertain, as no fossils were found in them, but they probably belong to the Tertiary.

[a] Brooks, A. H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, p. 559.
[b] Ibid.
[c] McConnell, R. G., A summary report of the Geol. Survey Dept. for the year 1900, Ottawa, No. 26, p. 45.

A lignite horizon, with one or more seams, occurs in this formation at a number of widely separated points, and apparently accompanies it throughout its whole extent. Lignite seams outcrop on Rock Creek and its tributary Coal Creek, at the northern end of the area, on Cliff Creek at the southern end, and on Twelvemile Creek, Fifteenmile Creek and Coal Creek at intermediate points, and are reported from a number of other localities. The total area underlain by lignite is estimated to considerably exceed 200 square miles.

The Alaska Exploration Company has taken up a block of coal lands on Coal Creek, and has commenced mining operations at a point a little over 7 miles from Klondike River, following Coal Creek and Rock Creek valleys, and about 20 miles from Dawson. * * * The workings of the mine consist of an incline about 400 feet in length, descending in a southeasterly direction at an average angle of about 25° for the first 200 feet, beyond which the angle gradually decreases to about 4°. A short drift has been driven in a northeasterly direction, following the seam, at a point 225 feet from the mouth of the incline. The seam dips to the northeast in a drift at angles of from 3° to 10°.

The strata in the upper part of the incline have been disturbed and faulted to some extent, and the lignite beds occur in a broken condition. In the lower part of the incline and in the drifts the beds are continuous, although the dips are still irregular. * * * Two seams of lignite are present in the lower part of the incline and in the drifts. The upper seam shows 3 feet of hard lignite and the lower from 2 to 3 feet. The two seams are separated by a clay parting about a foot thick and are roofed and floored with clay. The lignite is hard and compact and shows no traces of the woody fiber so common in lignites. * * * It is of good quality, burns freely, and can be used both for heating and steam purposes.

The following analyses of the two seams have been furnished by Dr. Hoffmann:

Lignite from upper seam, Coal Creek mine.

	Per cent.
Hygroscopic water	18.31
Volatile combustible matter	34.96
Fixed carbon	40.88
Ash	5.85
	100.00
Coke, percentage (noncoherent)	46.73

Lignite from lower seam, Coal Creek mine.

	Per cent.
Hygroscopic water	19.37
Volatile combustible matter	33.85
Fixed carbon	37.45
Ash	9.33
	100.00
Coke, percentage (noncoherent)	46.78

* * * * * *

The North American Trading and Transportation Company has opened up a group of lignite seams at Cliff Creek, a small stream which enters the Yukon from the right 55 miles below Dawson. The workings are situated about a mile and three-quarters from the mouth of the creek and consist of two long tunnels with a number of drifts and upraises. The lower tunnel is on the right side of the creek and the upper a short distance farther up the creek on the left side. The distance along the zone from the mouth of the first tunnel to the end of the second is 2,800 feet, and the seams appear to be continuous for this distance and probably extend much farther.

The tunnel at the upper workings has been driven mostly along the lignite zone for a distance of 800 feet. At one point, 225 feet from the mouth of the tunnel, the

coal seams are bent to one side and probably faulted. The lignite zone, consisting of alternating beds of lignite, clay, and carbaceous shale, measures over 40 feet in thickness in places. The included lignite seams vary in thickness from a few inches up to 5 feet. A section 300 feet from the mouth of the tunnel showed over 11 feet of coal in seams separated by clay partings and beds, as follows:

	Ft.	In.
Lignite	1	6
Thin parting		
Lignite	0	5
Carbonaceous shale	0	3
Lignite	0	6
Shale	0	1
Lignite	2	0
Clay	1	3
Lignite	1	3
Clay	3	0
Lignite	1	0
	11	3

The beds have a nearly east and west strike, and dip in a southerly direction at angles of from 50° to 75°.

A section in the lower workings showed:

	Ft.	In.
Shales		
Lignite, one thin parting	9	0
Shales	2	0
White clay	2	9
Alternating clays and shales	3	0
Grayish clay	13	0
Carbonaceous clay	3	3
Lignite, one parting	3	0
Carbonaceous shales and clays	6	0
Soft sandstone with layers of grit	10	0
	52	0

The dip of the beds in the lower workings is much less than in the upper, and in places they are almost horizontal.

The Cliff Creek lignite is very similar in appearance to the Rock Creek variety. It is dark in color, compact, and probably somewhat harder than the latter, as the inclosing rocks are more indurated. Dr. Hoffmann describes it as a lignite of superior quality closely approaching to a lignite coal. The following analyses were made in the laboratory of the Survey:

Lignite from upper and lower working, Cliff Creek.

	Upper working.	Lower working.
	Per cent.	*Per cent.*
Hygroscopic water	8.57	10.58
Volatile combustible matter	42.04	40.10
Fixed carbon	45.77	46.74
Ash	3.62	2.58
	100.00	100.00
Coke	49.39	49.32

Analysis by fast coking.

Coke of lignite from upper working, feebly coherent, tender.

Coke of lignite from lower working, noncoherent.

A considerable quantity of coal from Cliff Creek mines was shipped to Dawson during the past season for heating purposes, and it is also used by a number of the river steamers with satisfactory results. The coal is sold on the wharf at the mouth of Cliff Creek for $10 a ton, and in Dawson for $20 a ton and upward. A narrow-gauge railway has been built from the workings to the river, and the mine is now in a condition to supply a large demand.

The writer visited Coal Creek in the course of the present investigation. This stream joins the Yukon from the right, about 4 miles above the mouth of Cliff Creek. It flows nearly west, and forks about 6 miles from the Yukon. Coal has been located on both forks. The localities visited by the writer are on the main or east fork about 10 to 12 miles from the Yukon.

The coal-bearing sandstones lie unconformably on the edges of older schistose rocks which are exposed occasionally along the trail from the river up to within a mile of the coal croppings.

The main creek, where it cuts the coal-bearing beds, flows approximately west and probably follows the axis of an anticline.

Coal seams were examined in three places. In the upper opening a tunnel 100 feet long runs into the hill south of the creek on a coal bed which has been crushed and broken either by a local surface slide or by a fault. About one-fourth of a mile west of this point a slope tunnel (dip 33° S., strike N. 60° E.) was being driven into the south bank of the creek, in which the following section was exposed:

Section on south bank of Coal Creek.

	Ft.	in.
Coal	0	6
Clay parting	0	2
Coal	4	6

Above the coal is a soft, slippery shale, which the miners called "soapstone." The floor of the coal bed is a similar "soapstone," below which there is harder sandstone containing fossil leaves.

One-half mile west nearly 20 feet of coal outcrops in the north bank of the creek, with the following section:

Section on north bank of Coal Creek.

	Ft.	in.
Coal with 5 mining partings, all under 1 inch	14	0
Bony coal	2	0
Clay	1	0
Coal	0	18

A comparison with these two sections suggests that there are two workable coal seams in this locality.

The soft sandstone underlying this bed and the clay seam included in it carried abundant fossil leaves, the most common species being conifers, referred by Knowlton to the Upper Eocene. The coal can,

therefore, be considered Kenai. The coal contains much amber or fossil resin. Some specimens were almost one-half amber in grains distributed through the mass. In this respect they resemble the coals found on Washington Creek, in American territory.

Analyses made of the samples from the 5-foot seam above described were made by E. T. Allen. They are as follows:

Analysis of coal (sample No. 26) from Coal Creek, near foot wall of seam.

	Per cent.
Water	10.58
Volatile combustible matter	38.42
Fixed carbon	31.54
Ash	19.46
	100.00
Sulphur	.80
Fuel ratio	.82

Analysis of coal (sample No. 25) from Coal Creek, middle of seam.

	Per cent.
Water	12.57
Volatile combustible matter	39.54
Fixed carbon	41.98
Ash	5.91
	100.00
Fuel ratio	1.06

No coal has yet been mined on a commercial scale on Coal Creek. On the main fork of the creek the openings into the coal are low, and the dip will no doubt throw the coal below water level. Exploitation of the seams will therefore require hoisting and pumping, and a railroad not less than 10 miles in length to carry the coal to the landing on the river.

In working the Cliff Creek mine it is found that the frost in the coal extends to a depth of 150 feet below the surface. The unfrozen is of better quality than the frozen coal.

Mission Creek.—Mission Creek enters Yukon River from the west at the town of Eagle, 12 miles below the international boundary. The creek flows eastward and has a length of about 15 miles. An area of coal-bearing rocks from 3 to 4 miles wide extends back from the Yukon for a distance of 6 or 7 miles on the south side of this creek. The northern and southern limits of this basin are fairly well known, but whether its western end is connected with the similar coal-bearing rocks reported to occur on Seventymile River could not be determined in the brief time at the writer's disposal. Attempts have been made to open coal mines within this field on American Creek and Wolf Creek, southern tributaries of Mission Creek.

The coal seams of the Mission Creek field are contained in gray shales associated with conglomerates varying from incoherent gravel to hard

conglomerate, in which the pebbles break before the cement. Lumps of coal and knife-edge seams of lignite were found in this conglomerate. A few specimens of fossil plants were obtained from the shales, showing that they probably belong to the Kenai series and are certainly not older than the middle of the Cretaceous.

The coal-bearing formation rests unconformably on an older series of rocks made up of green slates, cherts, tuffs, and limestones, tentatively correlated by the writer with the Rampart series and believed to be of Devonian age. These are well exposed in the bluff immediately below Eagle, which extends along the north side of Mission Creek in an almost straight east-west line, suggesting a fault scarp. The coal-bearing rocks seem to end abruptly at the foot of this bluff, but they overlap the older rocks to the south and are found forming the hilltops, but have been removed by erosion in the valleys. The structure seems to consist of low open folds.

The coal of this belt is black, has a conchoidal fracture, and shows no traces of woody structure. In 1897 E. C. Barnard collected a sample from American Creek which had the following composition:

Analysis of coal from American Creek, 3 miles from Eagle.[a]

[Analyst, W. F. Hillebrand, U. S. Geol. Survey.]

	Per cent.
Water	6.75
Volatile combustible matter	39.13
Fixed carbon	37.59
Ash	16.53
	100.00
Sulphur	3.40
Fuel ratio	.96

This coal was noncoking.

Attempts have been made to open coal veins on American Creek and also on Wolf Creek, but during the summer of 1902 nothing was being done at either place and no definite information could be obtained regarding the coal seams.

It is reported that a coal bed outcropping a short distance below the crossing of the Eagle-Valdes trail has been opened up and abandoned twice. About 4 miles up Wolf Creek, in the material thrown out of a prospect hole near the creek, there were pieces of coal probably having a high percentage of ash, and some soft sandstone. A coal seam is reported to have been located on a small western tributary of Wolf Creek near this locality.

At the present time these coal deposits are unopened and are of no economic importance except as indicating the extent of the coal-bearing rocks in Alaska. The United States military post at

[a] Brooks, Coal Resources of Alaska, p. 565.

Eagle would afford a market for a limited amount of coal, and it is not probable that workable beds would be neglected if they had been found.

Seventymile River.—This river enters the Yukon 25 miles below Eagle and 37 miles below the international boundary. It has a length of about 75 miles and flows nearly due east to its junction with the Yukon. Coal is reported to have been found on this river and its tributaries several miles from the Yukon, but the writer was unable to obtain definite information regarding the occurrence. A great thickness of Kenai sandstone, not known to be coal bearing, is exposed at the mouth of Seventymile River. These coals of Seventymile River, if there be any, are undeveloped and are not known to be of economic importance.

Washington Creek.—This stream, which is about 40 miles long, enters the Yukon about 80 miles below the international boundary. Its headwaters oppose those of Seventymile River.

The accompanying sketch map (fig. 1) shows the geologic relations of the three formations exposed along the creek. Near the Yukon is a broad belt of black slates of Lower Cretaceous age. These rocks overlie (see fig. 1) an intricate succession of limestones and tuffs belonging to the Rampart series, which occupy a belt about 2 miles wide, through which the creek has cut a narrow gorge. Both series are closely folded, the axes of the folds running about east and west. To the south is an area of coal-bearing sandstones, conglomerates, and shales, whose southern limits were not determined. These beds are thrown up into broad, open folds, with dips of less than 45°, and overlie the older rocks unconformably. No fossils were found in this arenaceous series, but on lithologic and structural grounds it is correlated with the Kenai. This view is substantiated by both the character and the mode of occurrence of the coal. These coal-bearing rocks first outcrop about 9 miles from the Yukon, in a great bluff of slightly consolidated conglomerate, rising about 100 feet from the creek bed. The strike here is to the northeast, and the dip at a low angle to the southeast. This is believed to be the base of the coal formation, since, if the dips are continuous, it underlies the area of coal-bearing rocks. Above this point the valley of Washington Creek broadens out into a wide, flat basin, with little relief, within which the creek meanders through long, quiet pools, with small ripples between. Few exposures of bed rock occur, although there is a great quantity of float coal on the gravel bars for a distance of 5 or 6 miles above, which is as far as the writer traversed the creek. The prospect holes have caved in, so that for details of the coal sections the writer has been obliged to depend on the measurements made by prospectors. Their reports show a series of coal seams interbedded with soft sandstone and shale in several places, resembling, in a general

way, the coal seams at Cliff Creek and Coal Creek, in Canadian territory, which have been described.

At a point 1½ miles above the beginning of the coal-bearing forma-

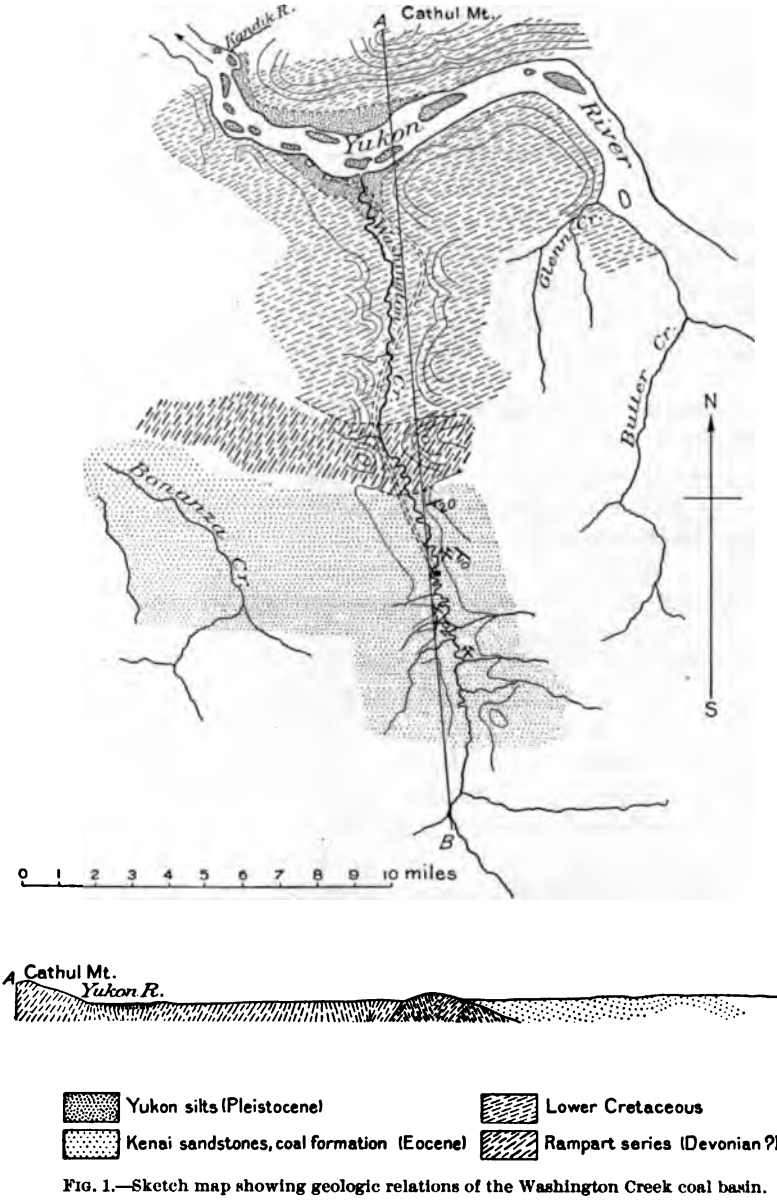

FIG. 1.—Sketch map showing geologic relations of the Washington Creek coal basin.

tion Messrs. Walter Stanford, J. W. Pratt, W. S. Layman, and F. L. Jewett opened a coal bed on the right bank of the creek and took out 5 tons of coal, which were hauled by dog teams to the river bank for the purpose of a steaming test on the river. The work was done

in the winter, without timbering, so that the opening caved in with the summer thaw. The beds dip southeast at 35°, and the following section is reported:

Section on Washington Creek.

	Ft.	in.
Coal	1	0
Clay	0	1
Coal	1	6
Clay	0	1
Coal	4	0
Fire clay	0	1
Coal	1	6
Carbonaceous shale	12	0
Clean coal	4	0

About 2 miles above this point, on the left bank of the creek, the Alaska Coal and Coke Company has opened coal beds in a hill rising from 100 to 300 feet above the creek, where the following section is reported:

Section at coal mine of Alaska Coal and Coke Company on Washington Creek.

	Feet.
Sandstone	
Coal	5
Thin bands of shale and coal	20
Coal	4

The coal outcrops for 700 feet along the strike, and the dip is about 45° SE.

Between these two points outcrops of coal were seen by the writer in the creek bank, which is about 15 feet high and capped with gravel covered by a deep tundra growth. The coal seemed to lie nearly horizontal in the cropping.

Mr. N. B. La Brie, of the Alaska Coal and Coke Company, reported a section on the creek showing about 30 feet of coaly shale, in the middle of which there are two seams of clean coal with 2 feet of "dirt" between. The lower seam is 4 feet thick and the upper from 2 to 3 feet. There is no apparent difference in the character of the coal of the two seams. The coal dips to the east at an angle of 40°.

On the right bank of the creek, some distance above the workings of the Alaska Coal and Coke Company, a section is reported to have shown 30 feet of coal and shale, but only 12 feet were exposed at the time of the writer's visit. The rocks dip 45° SW. and show the following section:

Section on right bank of Washington Creek above Alaska Coal and Coke Company's mine.

	Ft.	in.
Clean coal, with several small streaks of clay	5	6
Dirty coal	2	6
Sandstone	2	0
Shale	0	2
Coal	2	0

The coal beds where examined showed no signs of crushing or faulting. The evidence in hand points to the conclusion that there is a large area of coal-bearing sandstone on Washington Creek containing one or more thick zones of coaly material, in which there are several seams of clean coal that are not injured by faulting or crushing. The greater part of this coal, however, lies below the level of the drainage of the region, and in its development pumping and hoisting plants will probably be necessary.

Samples of the coal were taken at several places, both from the prospect pits and from the float in the creek gravel. These samples show a general similarity. The coal, though black and glossy and exhibiting a conchoidal fracture, has a lignitic appearance, often showing a woody structure. It is characterized throughout by grains and streaks of amber, or fossil resin. Large pieces of float coal, some weighing 50 pounds, were found on the gravel bars of the creek and showed little tendency to check or slack.

Analyses were made by Dr. E. T. Allen, United States Geological Survey, of one sample, taken by the writer from a 5-ton lot mined by Messrs. Stanford, Pratt, Layman, and Jewett, and hauled to the Yukon to be tested on a river steamer; and of another collected by Kasper Ellingen from one of the prospects of the Alaska Coal and Coke Company, on Washington Creek, about 1½ miles above the locality where the first sample was taken.

Analysis of coal (No. 75) from Washington Creek, 10 miles from Yukon River.

[Sample taken by the writer from a 5-ton sample mined for steam test.]

	Per cent.
Water	13.48
Volatile combustible matter	43.74
Fixed carbon	39.68
Ash	3.20
	100.00
Sulphur	.24
Fuel ratio	.91

Analysis of coal (No. 313) from Washington Creek, 1½ miles from Yukon River.

[Sample taken by Kasper Ellingen, of Alaska Coal and Coke Company.]

	Per cent.
Water	11.13
Volatile combustible matter	42.57
Fixed carbon	44.20
Ash	2.10
	100.00
Sulphur	.26
Fuel ratio	1.04

Neither of these samples was sealed up immediately on being taken from the mines, and it is probable that the percentage of moisture in freshly mined coal would be somewhat higher than is here shown.

The 5-ton sample, above referred to, was tested on the Northern Commercial Company's steamer *Sarah*, and is reported to have given entire satisfaction, as compared with the other Yukon River coals.

Coal was discovered on Washington Creek by Mr. N. B. La Brie in 1897, and soon after coal claims were staked along the west side of the creek. Later these locations were turned over to the Alaska Coal and Coke Company, of which Mr. La Brie is manager. Several years later claims were staked on the east side of the creek by Messrs. Stanford, Layman, Pratt, and Jewett.

Developments are as follows: The Alaska Coal and Coke Company has a drift tunnel 60 feet long and a slope tunnel 106 feet on the coal bed at a point about 12 miles from the Yukon. Five tons of coal have been mined from workings that have since caved in at a point about 10 miles from the Yukon. A good winter trail has been opened from the landing on the Yukon, near the mouth of the creek, to the coal beds, a distance of 10 to 12 miles, along which coal can be sledded with horses or dog teams during the winter. Should the demand for coal on the Yukon justify it, a railroad can easily be built into the coal basin.

Bonanza Creek.—This stream, which parallels the Yukon at a distance of about 6 miles from it, is an eastern tributary of Charlie River. The coal field reported on it is probably within 6 miles in a direct line from the Yukon, but by way of Charlie River the distance is much greater. The position of the creek on the accompanying map (Pl. II) is taken from a map by E. J. Chamberlain.

The bed rock along the Yukon consists of dark slates (Lower Cretaceous), which probably extend southward for some distance, but in the divide between the Yukon and Bonanza Creek there are some rough hills, suggesting the rocks of the Rampart series. The coal-bearing rocks probably overlie these harder rocks, making the geologic relations on Bonanza Creek similar to those found on Washington Creek.

The writer has been informed by many prospectors who have visited this region that extensive beds of coal are exposed, but owing to their distance from the Yukon no attempt has been made to exploit them.

Coal Creek.—This stream is a tributary of the Yukon, entering from the south side about 45 miles above Circle and 105 miles below the international boundary. The coal reported is 6 miles from the Yukon, and was not visited by the writer. Coal Creek probably has a length of about 30 miles. For some distance up from the mouth of the creek the bed rock is slate, resembling that along the lower part of Washington Creek, and is believed to be of Lower Cretaceous age. The coal is probably contained in Kenai sandstones and conglomerates which overlie this slate.

Specimens of float coal were picked up on the gravel bars of Coal

Creek, which show the character of the coal to be similar to that of Washington and Cliff creeks, in that it contains fossil resin, or amber. The coal on Coal Creek is not known to be of economic importance, and attempts to exploit it have been abandoned.

Nation River mine.—Tahkandit or Nation River enters the Yukon from the north about 52 miles below the international boundary. On the published maps of the Yukon this river has been called Tahkandit. It is more generally known at the present time as Nation River, and the coal mine formerly operated there is known as Nation River mine. It is located on the left bank, about 1 mile from the Yukon. Coal has been found at one locality only, though a formation probably identical with that which carries the coal extends down the Yukon for a distance of at least 10 miles, and it is probable that coal will be found at other places.

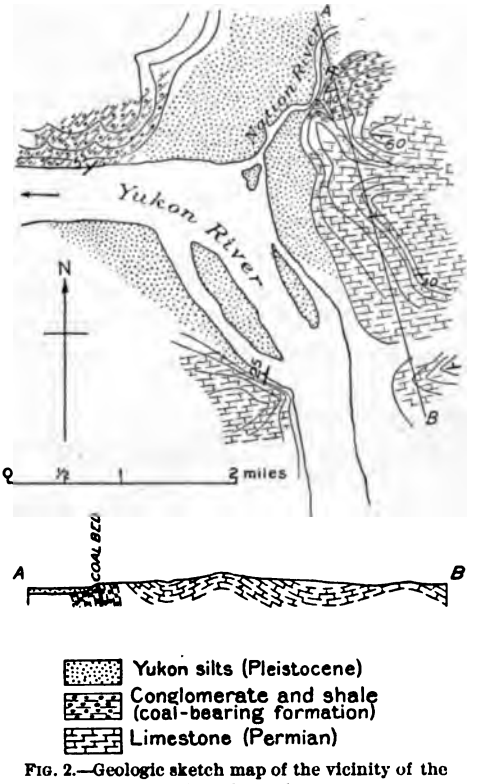

FIG. 2.—Geologic sketch map of the vicinity of the Nation River mine.

The coal at Nation River occurs in gray shales interbedded with heavy conglomerates. Both the coal and the inclosing rocks show the effects of intense crushing. In the conglomerate this is evinced by a cleavage developed in the quartz and chert pebbles of which it is composed. The geologic relations, as far as they are known, are shown on the accompanying sketch map and section (fig. 2). The coal-bearing rocks outcrop in the face of a bluff which rises about 200 feet from the creek bed. The strike here is approximately N. 60° E., and the dip is southeast, at an angle of 40°. About half a mile south of this point massive limestones outcrop, striking N. 70° E., and dipping southeast at an angle of 60°. These limestones form a belt of broad, open folds that lie south of the coal-bearing rocks and carry fossils of Permian age. Unless there has been faulting, of which there is some evidence, the Permian limestones overlie the coal-bearing formation. There is no direct paleontologic evidence as to the age of the coal-bearing rocks, as no fossils were found in them. In similar sandstones, how-

ever, several miles up the river from this place, plant fossils, possibly Paleozoic, were found.

The weight of the evidence seems to point toward a Permian age of the coal, though it is possible that the beds are of later age, infolded and overthrust by the Permian limestone. The following facts point to the latter conclusion:

First. The Eocene coals of this region generally are found in shales interbedded with conglomerates which are similar to these, except for the extreme crushing here shown.

Second. There is a great deal of heavy conglomerate and interbedded shale along the Yukon in this vicinity, varying greatly in the degree of consolidation, but showing a general lithologic similarity, and fossil plants from some of these rocks have been determined definitely to belong to the Kenai formation.

Third. Both above and below Nation River the sandstones and conglomerates are intensely folded and faulted, and the formations are often overturned. A few miles above Nation River, conglomerates which are younger than the Carboniferous are overlain by belts of Carboniferous age. This relation has been brought about by a thrust fault. In this vicinity the conglomerate sandstone series shows an overturned fold, which has brought slates believed to be Paleozoic above them. A similar explanation may account for the relations of the conglomerate and Permian beds at Nation River.

Fourth. Mr. W. E. Williams, who was manager of the Nation River coal mine while it was in operation, reports that in following the coal downward the dip became vertical and afterwards overturned, so that the dip, which at the surface was to the southeast became northwestward.

More extended and more detailed work in this vicinity is required to determine definitely the age of this coal. Should it be found to be of Carboniferous or Permian age, which seems doubtful, it would be important as indicating the possible presence on the Yukon of deposits of the older coals. In 1899 Brooks found a series of Carboniferous strata about 240 miles southwest of this locality that contained beds of impure coal, which he described as follows:[a]

Coal has been reported from the region of the upper White and Tanana rivers, but during our reconnaissance of the past season we saw no beds of coal which would be of commercial value. At a number of places carbonaceous shales of Carboniferous age were found, but none of these were sufficiently pure to use for fuel. One of these was about 10 miles west of Kershaw River, near our route of travel. At this locality beds of carbonaceous material some 20 or 30 feet in thickness were exposed. Much of it had been altered to graphite by dynamic metamorphism. Near the upper end of Lake Kluane similar beds were found. On Kletsan Creek carbonaceous shales containing a little bituminous coal were found, but the coal was too impure to have any fuel value.

[a] Reconnaissance from Pyramid Harbor to Eagle City, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 382.

The fossils collected by Brooks at this time were of a fauna similar to that of the Nation River limestones, and Schuchert, who examined them, and who has also examined the larger collections made on the Yukon by the writer and the collection made in the Copper River Basin by W. C. Mendenhall, is now of the opinion that these beds should be correlated with the limestones at Nation River.

Only one bed of coal has been found at Nation River. The mine workings are abandoned, and, having caved in, could not be examined. The face of the bluff on which they are located is subject to local slides, by which the outcrops of coal are covered. A recent prospect hole near the top of the bluff showed about 2 feet of crushed coal and shale standing nearly vertical.

W. E. Williams, who was superintendent of the mine, informed the writer that the coal bed here was never well defined. The coal was found in pockets and kidneys often as large as 8 feet thick and 13 feet long. When the mine was abandoned a large body of this kind that had been located was left unmined. Large pieces of this coal were found in the creek bed before the coal body was located.

The coal mined at Nation River is distinct in character from any other coal mined on the Yukon. It is a bituminous coal, containing a low percentage of water, and showing no traces of woody structure. If these coals prove to be of Kenai age, the differences in their composition may be accounted for by the greater degree of deformation which they have suffered. An analysis was made of a sample taken from a large pile, probably 100 tons, mined in 1898. It had been exposed to the weather on the river bank since that time, but apparently was not greatly altered. It had the following composition:

Analysis of coal (sample No. 68) from Nation River mine.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	1.39
Volatile combustible matter	40.02
Fixed carbon	55.55
Ash	3.04
	100.00
Sulphur	2.98
Fuel ratio	1.39

This coal makes a good coke in the laboratory. A large part of the coal was dry and unfrozen and of good quality, while a smaller part was frozen and almost worthless as fuel. The distribution of the frost was probably due to the circulation of water through the bodies of coal.

In 1897 the Alaska Commercial Company attempted to open a coal mine at this place, and about 2,000 tons[a] of coal were mined and

[a] For estimates of the amounts of coal produced at points along the Yukon the writer is indebted to Mr. W. E. Williams, a mining engineer, who has operated coal mines on the Yukon since 1897.

sledded to the Yukon, to be burned on river steamers or transported to the Dawson market. Owing to the irregularity of the coal deposit and the consequent uncertainty of the supply, and to the expense of mining, it was abandoned several years ago. During the summer of 1902 one man was prospecting and attempting to relocate the coal bed. This coal is of better quality than that of any other mine of the region, except for the large percentage of sulphur, but the disturbed condition of the seam makes it doubtful whether it can be worked at a profit.

RAMPART PROVINCE.

Under this heading the coal deposits of the Yukon between the flats and the mouth of the Melozi[a] will be considered.

Below Circle the Yukon for 200 miles meanders by numerous channels through a broad lowland known as the Yukon Flats. It then enters a more constricted portion of its valley, known as the Ramparts, which it leaves again at the mouth of the Tanana. Below the mouth of the Tanana the Yukon Valley broadens out. Within the flats the Yukon receives, from the north and east, Porcupine, Chandlar, and Dall rivers, and from the south, Birch Creek and Beaver Creek, besides many small streams. Below the flats, Ray River, Salt Creek, Sheflin Creek, Tozi (Tozikakat) River, and Melozi River are tributary to the Yukon from the north, and Hess Creek, Minook Creek, and Tanana River from the south.

The important settlements within this province are Rampart, the distributing point for a large placer-mining region, and Tanana, where the United States military post, Fort Gibbon, is located. During the summer of 1902 the United States Army maintained a telegraph line from St. Michael to Rampart. Telegraph stations were distributed along the river between these points at intervals of 40 miles.

One of the first attempts to mine coal on the Yukon was made about 25 miles above the present town of Rampart, on the site of what is now known as the Drew mine. Attempts to open coal mines have been made on Minook Creek near Rampart, on the Yukon 2 miles below Rampart, and on the Yukon 30 miles below Tanana.

Coal has been found on Dall River, which enters the Yukon at the lower end of the flats, and is reported by prospectors from Salt Creek, which enters the Yukon 20 miles below Dall River. Extensive coal beds also occur on Cantwell River, a southern tributary of the Tanana, about 100 miles south of Rampart. Several areas of sandstone correlated with the Kenai occur along the Yukon in this province in which coal has not yet been discovered.

The coal which has been developed in the Rampart province occurs

[a] This river is known in Alaska as the Melozikakat. Melozi is here used in accordance with the decision of U. S. National Board on Geographic Names, "kakat" being merely a native name for river.

A. DREW COAL MINE, 25 MILES ABOVE RAMPART, ON YUKON RIVER.

B. WILLIAMS COAL MINE, 90 MILES BELOW NULATO, ON YUKON RIVER.

in a sandstone series which, from its fossil plant remains, has been assigned to the Kenai. These beds are found in a small area near the town of Rampart, where they are over 5,000 feet thick and rest unconformably on indurated cherts and tuffs belonging to the Rampart (Devonian) series. Some of the beds are compact sandstones and conglomerates, while others are almost unconsolidated. Several other small areas of Kenai beds have been found in this part of the Yukon Valley, as is indicated on the map, Pl. II. An unsuccessful attempt has been made at mining a lignite seam which occurs in unconsolidated beds that contain Pleistocene fossils.

Drew mine.—The Drew mine is situated on the left bank of the Yukon, 25 miles above Rampart and opposite the mouth of Hess Creek. It is probably the oldest coal mine on the Yukon, and has been known, at different times, as the Miller mine and the Pioneer mine. It is the only coal mine that has been operated in the Rampart province, and there are no promising deposits of coal known along the main river within 300 miles either above or below it, so that it is probably the most important point for coal mining on the Yukon. A view of this mine, as it is seen from the river, is shown in Pl. V, *A*.

The coal-bearing formation at this place is confined to a great bend of the Yukon, and its known extent is not over 4 square miles. (See fig. 3.) Opposite the Drew mine the banks of the Yukon are low, and a broad flood plain extends for several miles up the valley of Hess Creek. The coal-bearing sandstones are probably continued beneath these flood-plain deposits, and may be connected with the coal-bearing formations exposed near Rampart, which have been described.

From Fort Hamlin to within a mile of this mine the Yukon flows in a canyon cut in a system of diabases and tuffs interbedded with the more or less cherty slates of the Rampart series. One mile above the Drew mine the rocks of the Rampart series are succeeded by a great thickness of sandstones, carrying fossil plants which have been referred to the Kenai series. Near the point of contact of these formations the Rampart rocks are hard, siliceous slates, with interbedded tuffs, striking N. 30° E. and dipping southeast at an angle of 70°, but the immediate contact is not exposed. The strike and dip of the sandstones appear to agree with those of the slates. Sandstone beds stand at a high angle, dipping away from the underlying rocks. From this point to the coal mine, a distance of 1 mile, there are frequent though not continuous exposures of sandstone standing at high angles. At the coal mine the sandstones are nearly vertical. If there is no close folding or faulting, with consequent repetition of these beds, their thickness should exceed 5,000 feet. The areal distribution and stratigraphic relations are shown in the sketch map and section, fig. 3.

In the lower 4,000 feet of this section no coal seams have yet been found. This portion is made up of fine-grained sandstones and shales

and a small amount of conglomerate. Fossil leaves, mostly of dicotyledonous plants, are distributed through it. In the upper part of the section coal seams are abundant and outcrop along the river bank. The coal is interbedded with fire clay and fine-grained sandstone. If there is no folding and consequent duplication of these beds, of which no evidence was observed, there are at least seven such coal seams dis-

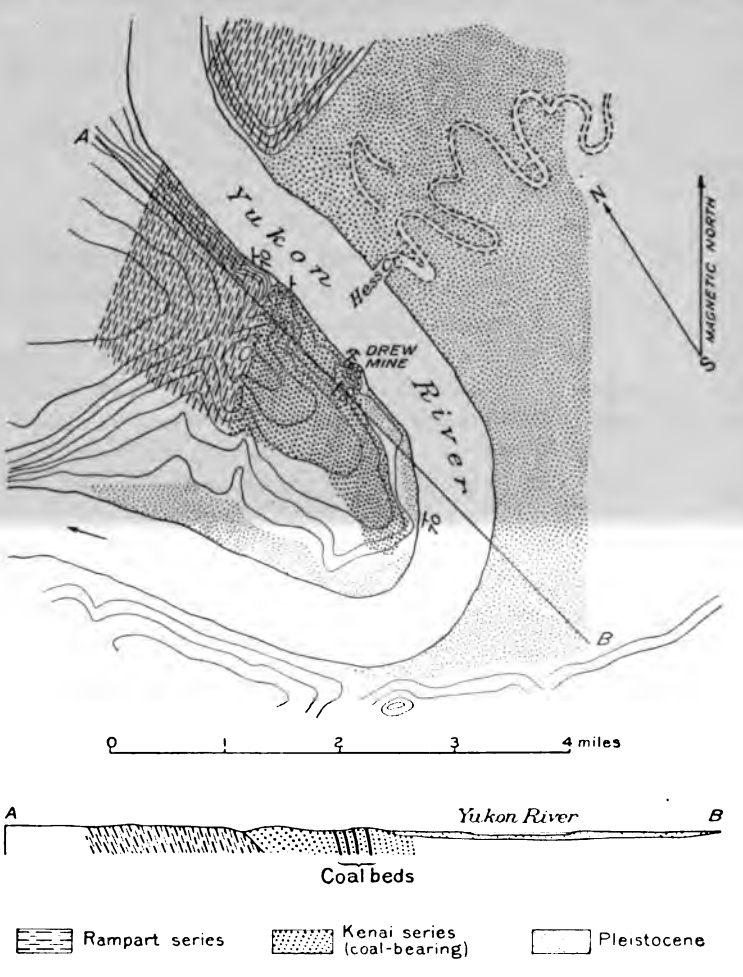

FIG. 3.—Geologic sketch map of the vicinity of the Drew mine.

tributed through less than 1,000 feet of sediments. Above these coal measures there are some heavy beds of coarse sandstone and conglomerate, aggregating in thickness 200 or 300 feet.

Although the outcroppings indicate that there are probably seven seams of coal at this place, only one of them has been exploited. The croppings of this seam in the river bank showed solid coal above the water line at the high stage of the river that prevailed at the time of

the writer's visit. The other seams were indicated only by broken coal or coal smut mixed with fire clay, although it is reported that at low stages of water several of these seams present measurable exposures at the water's edge.

The bed that has been opened is believed by the writer to be the sixth one from the bottom of the coal series. Within the mine this bed was found to consist of two seams, aggregating 38 inches of clean coal, contained in about 19 feet of coaly material. The section was as follows:

Section at Drew mine.

	Ft.	in.
Yellow, shaly sandstone	--	--
Bone and black shale	1	8
Coal	2	1
Black shale and bone	4	0
Coal	1	1
Black shale or bone coal	2	0
Coal	0	2
Black shale	4	0
Bony coal	4	0

Analyses by Dr. E. T. Allen of samples from each of the two seams of clear coal are as follows:

Analysis of coal (No. 137) from 13-inch seam, Drew mine.

	Per cent.
Water	9.58
Volatile combustible matter	36.87
Fixed carbon	39.83
Ash	13.72
	100.00
Sulphur	0.33
Fuel ratio	1.08

Analysis of coal (No. 138) from upper 25-inch seam, Drew mine.

	Per cent.
Water	9.54
Volatile combustible matter	40.09
Fixed carbon	37.35
Ash	13.02
	100.00
Fuel ratio	0.93

These analyses show a rather high percentage of ash, otherwise the coal compares well with that mined on the upper Yukon. The samples show some small specks of fossil resin, or amber.

About 100 yards north of the main workings of the Drew mine prospect holes have been sunk on another coal seam, probably the fifth of the series here exposed. About 7 feet of crushed coal is exposed in the pit, which tapers at the bottom to 4 feet of coal, also crushed and yielding no solid pieces. Grains of fossil resin, or amber,

are common in this seam. A sample of this weathered coal was analyzed and showed the following composition:

Analysis of sample (No. 312) of croppings of lower coal bed, Drew mine.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	14.44
Volatile combustible matter	47.15
Fixed carbon	33.77
Ash	4.64
	100.00
Fuel ratio	0.72

This analysis shows a lower percentage of ash than the coal from the seam which has been worked. The higher percentage of water is in all probability partly the result of weathering of the coal at the outcrop.

Coal was first discovered at the Drew mine and developed by Oliver Miller in 1897. Spurr reports that in that year a tunnel 40 feet in length had been driven into the hill on a 2-foot seam, probably the 2-foot seam of the present mine.[a] Drew worked the mine several years since that time, but it is now closed under an attachment suit instituted by the Northern Commercial Company.

The equipment of this mine consists of a shaft 75 feet deep, cribbed, housed, and provided with steam hoisting gear. Bunkers of 80 tons capacity are conveniently situated with chutes to reach the decks of steamers moored at the river's bank. The shaft was found to be in good condition and the mine free from water and of ice except for 6 inches at the bottom. A gangway about 20 feet long from the bottom of the shaft crosscuts the sandstone to the coal bed, and then turns and follows the coal for several hundred feet. The writer was prevented from reaching the end of this gangway by a cave-in in the old workings, about 40 feet from the turn. The coal from the 2-foot seam has been stoped out above this gangway. An air duct which has been driven along the 13-inch seam represents all the work on this smaller seam.

About 1,200 tons of coal have been taken out of the Drew mine, the greater part of which was used on river steamers. The coal has not given entire satisfaction for this purpose. This dissatisfaction was due, in part, no doubt, to the inexperience of the firemen and the unsuitable grates which were used. It is also reported that the coal was carelessly mined, so that as supplied at the bunkers it contained a great deal of unnecessary dirt, but it nevertheless sold readily at $15 per ton. The following statement regarding it, by Mr. H. N. Wood, assistant engineer, United States Revenue-Cutter Service, is taken from Mr. Brooks's paper on Coal Resources of Alaska (p. 564):

My experience with Yukon coal was limited to a trial of the coal of but one of the Yukon River mines. This was that from the one known as Drew's mine, which is

[a] Spurr, J. E., Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 381.

located on the bank of the Yukon directly opposite the mouth of Hess Creek. An attempt was made to steam the boilers of the United States steamer *Nunivak*, using this coal alone, but without success. Used mixed with Comox coal in the proportion of two parts of Yukon to one part Comox, moderate steaming could be done. Used with wood, it served fairly well, about 400 pounds being used with one cord of wood. Used to maintain low-banked fires when the engine was stopped, it seemed to be fully as good as Comox coal. If, however, a fire was wanted to furnish steam for running a 10-kilowatt dynamo, the Yukon coal was inferior, due chiefly to the waste caused by the sifting of the coal through the grates when the fires were disturbed with fresh coal or fire tools. Although the attempt to steam with this coal was a failure, I am of the opinion that with some experimenting to determine the best kind of grates, amount of grate surface and draft most suitable, and the proper way to handle the coal in the furnace, good results could be obtained. Judging by my limited experience, the Yukon coal will compare with Comox coal and with wood about as follows, using the average hourly consumption of the *Nunivak* as a basis: 1,200 to 1,500 pounds Comox coal equal 2,000 to 2,500 pounds of Yukon coal, equal 1¼ to 1½ cords of spruce wood. Comox coal was on the market in St. Michael in 1899 at $15 per long ton. The same price was charged per short ton for the Yukon coal at the mine. The cost of wood is from $6 to $10 per cord.

At the point where this mine was opened a low hill rises about 200 feet above the river, affording a considerable amount of coal above the river level that could be stoped down into a main gangway driven in directly from the river bank. Behind this hill there is a broad depression, nearly one-fourth mile wide, cutting off the greater part of this coal seam. Beyond this depression there is again high ground, reaching an elevation of from 400 to 600 feet above the river. The greater part of the coal above water level in the hill near the river has probably been mined. In extending the mine along the strike of the bed there will be a limited amount of coal to be mined above the gangway at the present level until the higher hill is reached. Here, if this bed holds its thickness and is not displaced by faulting or folding, a large amount of coal will be found that can be readily stoped down into a gangway at the present level. It is also probable that further prospecting may show some of the other coal beds here exposed to be of economic importance. Most of these beds are well situated topographically for yielding a continuous supply of coal.

Minook Creek.—This creek enters Yukon River from the south side, about 1 mile above the town of Rampart. It has a length of about 20 miles, heading in the Yukon-Tanana divide, opposite the head of Baker Creek, which flows to the Tanana. Sandstones carrying some coal seams outcrop along the left bank of the Yukon for 3 or 4 miles above Minook Creek and also about 2 miles below the town of Rampart. They form the floor of Minook Creek Valley for 2 miles above its junction with the Yukon. They are best exposed in a bluff along the left bank of the Yukon for several miles above the mouth of Minook Creek. The strike of the beds at this place is constant, N. 70° E., while the dip increases from 20° near the northern end of the outcrop to 50°

near the southern end. They consist of almost incoherent sands and gravels.

Fossil leaves collected in the bluff along the Yukon above the mouth of Minook Creek were assigned by Knowlton to the Kenai series represented at the Drew mine, and the rocks are, therefore, probably continuous between the two points, though this connection has not been established by actual observation. The lithologic character of the Minook beds differs widely from that of the sandstone at the Drew mine, and without the fossil evidence would suggest that they belong to a younger horizon. At both localities the coal-bearing sandstones rest unconformably on rocks belonging to the Rampart series. Impure lignites occur in these sandstones at several points above Rampart. On Minook Creek about 2 miles from the town of Rampart these lignite beds are reported to have occasionally been on fire. Attempts have been made to open a coal mine at the latter place, but Mr. Paige, of the Geological Survey party, who visited the locality, reported that the workings had caved in, so that the thickness of the bed could not be determined. A sample of the coal was taken for analysis from the dump of the old prospect hole.

The coal is a glossy lignite which tends to break up into small cubical grains on drying. The analysis is as follows:

Analysis of coal (No. 310) from junction of Hunter and Minook creeks.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	11.21
Volatile combustible matter	44.32
Fixed carbon	38.64
Ash	5.83
	100.00
Fuel ratio	.87

The percentage of water in freshly mined coal from this locality would probably be considerably higher than the analysis shows, since the sample analyzed had lain out on the dump all summer and was very much checked up by drying. Samples of coal from this locality have been tested for heating purposes by the miners at Rampart, and are reported to have been rather unsatisfactory in that the coal needed a certain amount of wood mixed with it to make it burn well.

Two miles below Rampart, on the left bank of the Yukon, a similar coal outcrops. This has been prospected to some extent, but the workings are at present abandoned and the tunnel has caved in. A sample taken from the dump of the old tunnel showed physical characters similar to that from Minook Creek.

The analysis is as follows:

Analysis of coal (sample No. 160) from left bank of Yukon 2 miles below Rampart.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	16.43
Volatile cumbustible matter	41.09
Fixed carbon	35.22
Ash	7.26
	100.00
Fuel ratio	.86

Coke noncoherent.

Between Rampart and the mouth of the Tanana, on the north side of the Yukon, there are two large areas of sandstones and conglomerates that have been correlated with the Kenai, which have been reported to carry beds of coal, but no coal of economic importance has yet been found in them.

Dall River.—On Dall River, about 70 miles from its junction with the Yukon, coal occurs which resembles the Rampart coal. The following description is quoted from Mendenhall's report:[a]

In the bed of Coal Creek, about 1 mile above its confluence with Dall River, there is an outcrop of lignite with irregular clay streaks, which measures, as far as can be determined from the imperfect exposures, approximately 11 feet in thickness. At the base of the exposure are 4 or 5 feet of firm, bright lignite, while the remainder is soft, dirty, and of poor quality. Blocks of the coal have been washed down the creek and some distance down Dall River without breaking up; but certain portions of the seam slake rapidly when exposed to the atmosphere. Although no opportunity was afforded for making practical tests, the lower 4 or 5 feet of this seam are believed to be lignite of good quality, while the remainder is probably of no value. This coal is contained in soft, gray, buff, or black shales, which are supposed to be Tertiary (Kenai series).

Salt Creek.—Coal has been reported on Salt Creek by prospectors. Little definite information was obtained regarding it. These seams are said to be about 25 miles from the Yukon and may occur in an extension of the same area of coal-bearing rocks as those of Dall River described by Mendenhall.

Palisade lignite beds.—On the left bank of the Yukon 35 miles below Tanana bluffs of buff-colored silt and gravel rise to a height of 150 feet above the river. This locality has been named the Palisades, but on account of the occurrence in the silts of abundant bones of the mammoth and other large mammals it is more popularly known as the Bone Yard. Silts of practically the same age occur in many places along the river. They are not known to carry lignite beds except at the Palisades.[b] These silts contain not only bones of the mammoth

[a] Mendenhall, W. C., Reconnaissance from Fort Hamlin to Kotzebue Sound: Prof. Paper U. S. Geol. Survey, No. 10, 1902. See also Brooks, A. H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 558.

[b] Spurr, J. E., Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 199 and 207.

and other mammals, but shells of fresh water and land gasteropods, represented by species now living, and cones of *Picea* resembling the present spruce of the Yukon Valley, which show that the silts are of Pleistocene or late Pliocene age. The material in these bluffs is mostly extremely fine silt, greenish gray in color, forming when wet a fine sticky clay and showing scarcely any traces of stratification. At intervals in this deposit there are thick beds of vegetable material containing wood in all stages of change from pliable sticks to brittle brown lignite. These beds vary in thickness and also in the nature of their material; usually, however, they contain trees, some of considerable size.

Near the upper end of the Palisade Cliffs a tunnel has been run on one of the lignite beds. In the summer of 1902, however, this tunnel had caved in, and the bed could not be examined underground. Mr. N. H. Wood,[a] assistant engineer, U. S. Revenue-Cutter Service, is authority for the statement that a vein 20 feet thick was reported here.

The lignite from this locality is of inferior quality, scarcely changed from wood or peat. Where examined by the writer this peat is mixed with red sand. Samples were taken, but no analyses of them have been thought necessary, as in the present stage of Alaskan development these beds have no value.

Cantwell River.[b]—This river is tributary to the Tanana from the south, about 130 miles from the Yukon. The Cantwell has its source well within the Alaskan Range, which it leaves through a narrow valley cut into metamorphic rocks. The front of the range is about 40 miles from the Tanana. At the northern flank of the mountains these metamorphic rocks are mantled over by coal-bearing, friable sandstones, which find topographic expression in a series of low hills running parallel to the front of the range. Lithologically the rock is chiefly soft, friable sandstone, often of an almost snow-white color, with some intercalated conglomerate and shale strata. The basal beds are usually conglomeratic. The entire series probably measures several hundred feet in thickness. Lithologically it closely resembles the Kenai beds exposed near Rampart on the Yukon. The series is either entirely undisturbed or is thrown up into broad, open folds. Faulting was observed at several localities.

The coal-bearing beds outcrop for about 15 miles along the river, and were traced about 4 miles to the east. The area of this coal field can be safely estimated at 60 square miles at least, and may be many times that. The beds are seldom exposed except along the river and stream valleys, for elsewhere they are usually deeply buried under Pleistocene gravels. These coal-bearing terranes were proba-

[a] Brooks, Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 557.

[b] This note was furnished by Mr. Alfred H. Brooks, in advance of the publication of his report to be entitled, "A Reconnaissance in the Mount McKinley Region, Alaska."

bly deposited in an isolated fresh-water basin. No fossils have been obtained from these rocks, but they are believed to belong to the upper part of the Kenai series or to a younger Tertiary horizon.

What promises to be workable coal beds were found at two localities during the hasty reconnaissance on which these notes are based. The most important of these are on Healy Fork, an easterly tributary of Cantwell River, which it joins from the east about 40 miles from the Tanana. The coal beds are well exposed in precipitous bluffs along the north valley wall of this stream. The strong contrast between the white sandstone and the black coal seams makes them very conspicuous features even from a distance. While the beds are largely made up of sandstone, yet the layers lying immediately adjacent to the coal are most often clay and sandy shales. One bluff about 2 miles from the Cantwell was examined in some detail. In this section 200 feet of sandstone and conglomerates formed the basement member, and rested unconformably on the phyllites of the metamorphic series. This bed was overlain by about 250 feet of soft sandstone shales and coal. In the entire section the coal aggregated about 125 feet in thickness, contained in about fifteen seams. Of this 125 feet probably 60 feet were of a fairly good grade of lignite. The largest seams were 20 feet in total thickness, but included considerable bone and shale. In character the coal varied from a fibrous, impure lignite, which is entirely worthless, to lignites which may have commercial value. The lignite of better grade is of a lustrous black color, and has a conchoidal fracture. The seams were accessible only along the outcrop, where they were made up of noncoherent lignite. A sample taken almost at random from one of the larger seams was analyzed by Dr. E. T. Allen, of the United States Geological Survey, with the following result:

Analysis of coal from Healy Fork of Cantwell River.

	Per cent.
Moisture	13.02
Volatile matter	48.81
Fixed carbon	32.40
Ash	5.77
	100.00
Fuel ratio	0.66

This analysis shows that the coal is a fairly good lignite. In considering it, it should be borne in mind that the short time given to the study of the locality makes it quite possible that seams of better grade were overlooked.

The second locality where lignites were found is on Lignite Creek, so-called, a few miles north of Healy Fork. At this place the croppings show fewer seams and these are of less thickness. These lignites, as far as determined, were of no higher grade than those of Healy

Fork. North of Lignite Creek, and apparently higher in the series, seams of fibrous impure lignites and carbonaceous shales are not uncommonly interbedded with the sandstones. It is not likely that any of these have any prospective commercial value. In the opinion of the writer the best coals in the basin are near the base of the sandstone series.

Topographically these coal seams are exceptionally well located for mining. Though they have been known since 1898, the isolation of the locality has precluded any possibility of their development. Should a railway ever be built through Caribou Pass from Cook Inlet, as has been proposed, it is quite possible that this coal field might receive development.

NULATO PROVINCE.

Under this heading the coal beds included in the large area of sandstone and shale extending from the Melozi to the mouth of the Yukon will be described. Within this province the Yukon flows with a slow current and is often divided into several channels. Along the right bank there is a series of bluffs and hills, rising generally to a bench from 100 to 400 feet above the river. On the left bank the flood plains extend back for a distance of from 5 to 20 miles, and the hills are usually not visible from the river. The writer does not know of any outcrops of bed rock along the left bank of the Yukon within this province. The most important tributaries from the north side are the Koyukuk, which is the largest, Nulato, Kaltag, Anvik, and Clear (or Andreafski) rivers. Yuka, Kaiyuh, and Innoko rivers are important southern tributaries. Nulato, the largest Indian village in the interior of Alaska, and the principal town in the province, is about 25 miles below the mouth of the Koyukuk. A trading post has been maintained here for many years. There is also a mission maintained by the Roman Catholic Church. A view of this village is shown in Pl. VI, *B*.

At Kaltag, a small trading post and post-office about 40 miles below Nulato, the telegraph line and winter mail route leave the Yukon and follow Kaltag River nearly to its head, then cross the divide to Unalaklik River, and extend down that river to Norton Sound. At Koserefski the Holy Cross Catholic mission is the chief institution. Below Koserefski, Pimute, and Russian Mission are Eskimo villages, and Andreafski furnishes winter quarters for a large part of the fleet of Yukon steamers.

In this field coal beds are found along the Yukon for a distance of 200 miles. These coal beds resemble one another both in the character of the coal and in its mode of occurrence, and in these particulars they differ from the upper Yukon coals. The coal-bearing sandstones outcrop along the right bank of the Yukon, which forms the south-

eastern boundary of this field, while south of the Yukon low flats extend for several miles to the foothills, which are composed of rocks believed to be older. Northward the field extends up Koyukuk River for a distance of at least 35 miles, and it extends westward probably to Norton Sound. At its northern and western boundaries it is overlain by younger effusives and sediments.

The coal occurs in beds which are not known to have great extension. These will be described under the headings Nahoclatilten coal bed, Pickart coal mine, Nulato coal bed, Bush mine, Blatchford mine, Williams (Clemens Thein) mine, Coal mine No. 1, and Halls Rapids coal. Reported coal prospects not visited by the writer will be mentioned under the headings upper Koyukuk and Anvik River.

Nahoclatilten coal bed.—Bluffs of sandstone extend up the west bank of the Yukon from Nahoclatilten[a] for about 20 miles, nearly to the mouth of Melozi River, and are coal bearing about 5 miles above the village. These coal seams were examined at only one locality by the writer. Coal has probably also been found at a number of places in this vicinity, which is roughly located about 50 miles above Nulato and on the right bank of the Yukon.

The geologic relations of these coals are of exceeding interest, though at the present time only imperfectly known. The coal seams were found about one-fourth of a mile from the river in sandstones and shales carrying Kenai fossils, and hence of Eocene age. This sandstone stands nearly vertical, and from it an ancient slide extends to the river. From the foot of this slide on the river bank fossil plants referable to the Middle or Lower Cretaceous were collected, as well as fossils referable to the Kenai. About one-fourth of a mile up the river from this point there is a high bluff composed in part of calcareous sandstone and in part of intrusive basalt. From the sandstone abundant marine fossils referable to the Upper Cretaceous have been collected.

Two beds of coal were seen by the writer at this place, and two more are reported to have been uncovered in prospecting. The largest observed seam has a thickness of 1 foot. Below this seam there are about 5 feet of bony coal or coaly shale with stringers of coal. There are reported to be three smaller beds in the foot wall, each having a thickness of 10 inches. Owing to the apparent rather intense folding of these beds it is impossible to place much reliance on these statements.

The coal in the 1-foot seam is not crushed, although the beds are much disturbed in position. The following analysis shows it to be a bituminous coal of good quality. It is reported to have given satisfactory results in a blacksmith's forge.

[a] The United States military telegraph post here located was officially known by this name in 1902, but in 1903 the name was changed to Louden.

Analysis of coal (No. 241) from 1-foot seam 5 miles above Nahoclatilten.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	6.88
Volatile combustible matter	41.82
Fixed carbon	48.93
Ash	2.37
	100.00
Sulphur	.65
Fuel ratio	1.17

Coke slightly coherent.

These coal beds have been known for several years, and various attempts have been made to open here coal beds of commercial importance, but thus far no seams thicker than 12 inches have been found.

Upper Koyukuk.—Near Tramway Bar, on the upper Koyukuk, a large coal bed has been reported by Schrader[a] and others. Tramway Bar is on the Middle Fork, 569 miles by river from the junction of the Koyukuk with the Yukon. It is 130 miles above Bergman and 50 miles above Bettles, and about 20 miles from the seat of placer-mining operations near Cold Foot. The following description of the geologic relations and extent of the coal-bearing formation is quoted from Schrader's report:

On the Middle Fork of the Koyukuk, about 5 miles above Tramway Bar, the metamorphic rocks give way to a younger rock series composed of impure sandstone, arkose, grit, and conglomerate, indiscriminately carrying more or less lignite and remains of fossil plants. On account of its fossil contents and its resemblance to the Kenai found elsewhere in the Yukon district this formation is provisionally referred to the Kenai, which is regarded by Dr. Dall as Upper Eocene. In some localities the beds are quite firmly consolidated, especially the sandstones, while in others they are sufficiently soft to be readily plucked away with a pick or hammer. In nearly all localities the beds show more or less disturbance and some faulting and folding. Above Tramway Bar they have a southerly dip. At Tramway Bar they consist of a belt of firmly consolidated conglomerates, 3 or 4 miles wide, through which the river has cut a canyon about 80 feet deep.

From Tramway Bar to below the Arctic Circle frequent exposures of sandstone, soft shale, and mud rock, carrying more or less imperfect plant remains, are met with. * * * Their attitude often varies, and they nearly always show more or less disturbance.

From this description it will be seen that coal-bearing rocks are exposed along the Koyukuk here for a distance of about 130 miles, though coal has been found at only one locality. In 1901 Schrader found that this series of sandstones extends up John River northward from the Koyukuk for 20 miles, and in the gravels of that stream he found pieces of coal of good quality.[b]

[a] Schrader, F. C., Reconnaissance along Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, pp. 441–486.

[b] Schrader, F. C., A reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20 (in press).

From comparison with similar sandstones seen in the Colville River drainage that year, Schrader came to the conclusion that the sandstones of the upper Koyukuk are probably of Upper Cretaceous age.[a]

The coal bed at Tramway Bar is described as having a thickness of nearly 12 feet, the middle 9 feet being comparatively pure lignite.

The following analysis was made of a sample collected by Schrader at this time:[b]

Analysis of coal from bed at Tramway Bar.

[Analyst, George Steiger, U. S. Geol. Survey.]

	Per cent.
Moisture	4.47
Volatile matter	34.32
Fixed carbon	48.26
Ash	12.95
	100.00
Fuel ratio	1.40

The coal does not make a coherent coke. From this analysis it will be seen that this coal should be grouped with the bituminous coals of the lower Yukon. The coal bed is practically undeveloped, but the coal has been locally used to some extent for blacksmithing purposes.

Pickart coal mine.—This mine, one of the oldest on Yukon River, is located 10 miles above Nulato, on the right bank, and 12 miles below Koyukuk River. Below the Koyukuk the Yukon flows nearly west to within a mile of the coal mine; then it turns abruptly to the south and follows along the foot of a series of sandstone bluffs, in which the coal is contained, and which are almost continuous to Nulato.

These sandstones carry plant fossils which have been referred to the Upper Cretaceous. At the coal mine these are probably fresh-water deposits, but they rest conformably on marine sandstones carrying abundant fossils, also referable to the Upper Cretaceous. The coal bed at the Pickart mine is stratigraphically about 75 feet above the contact of the marine and fresh-water beds. The sandstones between the coal beds and the marine beds are continuously exposed and show considerable cross bedding, but no evidence of unconformity or faulting. Above the Pickart coal there is a great thickness of sandstone carrying fossil plants, and one small coal seam. About 1 mile up the river fragments of sandstone carrying marine fossils of Upper Cretaceous age were found, which probably came from the sandstone overlying the coal bed, though they were not traced to their bed-rock source. These sandstones are exposed continuously along the river for 1 mile above the coal mine. In this distance the strike and dip frequently change, and there is probably some faulting as well as folding. Along this stretch the cliff face rises about 100 feet above the

[a] Schrader, F. C., A reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20 (in press).

[b] Coal Resources of Alaska, p. 565.

river, and from the cliff the hill slopes back more gently to an elevation of about 600 feet above the river, as shown by Gerdine's map of the mouth of the Koyukuk.[a]

At the Pickart mine one coal seam has been exploited, which strikes N. 75° E. and dips N. 35°. Two rolls, or horsebacks, are reported to occur in the floor of the coal bed. Whether these are in the nature of faults, due to movement of strata along the coal bed, or irregularities in deposition of the sediments constituting the floor, the writer was unable to determine. Near these rolls the coal shows considerable crushing, which suggests that the roll is caused by deformation. The Pickart coal bed has a thickness of 30 inches at a distance of 300 feet from the entrance to the mine, but at the end of the main gangway, 600 feet from the entrance, near one of the rolls above referred to, the seam measured only 18 inches. Mr. W. E. Williams, manager of the Pickart mine, reports that in mining this coal a roll was encountered in the workings above the main gangway, in which the floor of the bed was raised up, pinching the coal down to a knife-edge thickness. This roll extended in a nearly straight line and approached the gangway at the rate of about 1 foot in 20. On cutting through this roll good coal was found, having a thickness of 3 feet, which continued for about 20 feet, when another roll parallel to the first was encountered. The second roll has not been passed through in the workings of the mine. The coal near these rolls is crushed and impure and the bed pinches down to a knife-edge thickness. It is probable that coal will be found beyond the second roll in the floor, so that the commercial extent of the seam in this territory has not been determined, nor has it been traced below the river level.

The Pickart coal makes a good coke and must be classed as distinctly bituminous. Samples were taken from the main gangway 300 feet from the surface and from the end of the gangway 600 feet from the surface, and these were analyzed by Allen, of the United States Geological Survey. The second sample is interesting as showing the character of the coal in the vicinity of the rolls in the floor, which led to the abandonment of the mine.

Analysis of coal (No. 252) from Pickart mine, 200 feet from entrance.

	Per cent.
Water	1.02
Volatile combustible matter	27.33
Fixed carbon	65.03
Ash	6.62
	100.00
Sulphur	0.60
Fuel ratio	2.38

Coke compact.

[a] Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pl. lx.

Analysis of coal (No. 253) from Pickart mine, 600 feet from entrance.

	Per cent.
Water	1.64
Volatile combustible matter	24.98
Fixed carbon	58.18
Ash	15.20
	100.00
Fuel ratio	2.33

Coke compact.

This coal has been used for steaming purposes on the river boats for the last five years, but the reports regarding its steam-producing capacities vary greatly. Some engineers speak highly of it; others were dissatisfied with it. It should be borne in mind that, wherever coals have been tried for steaming purposes on the Yukon, they have been burned in grates designed primarily for wood, and that the firemen have, as a rule, been inexperienced with coal. Further, much of the coal has been mined within a few feet of the surface, where it was frozen when extracted, and after thawing it tended to break up into small pieces. In very few instances has the development of the mines gone far enough to obtain coal unaffected by atmospheric influences. The entire product of this mine was sold readily at from $10 to $15 a ton. The coal in the small 1-foot seam mentioned as occurring above the Pickart bed is similar in quality to the Pickart coal. It has no commercial importance. The analysis is as follows:

Analysis of coal (No. 251) from small vein above Pickart coal.

	Per cent.
Water	2.22
Volatile combustible matter	24.76
Fixed carbon	50.38
Ash	22.64
	100.00
Sulphur	0.56
Fuel ratio	2.03

Coke slightly coherent.

Mining was begun at this locality by the Pickart brothers[a] in 1898. A drift tunnel was first started from the river bank at such a level that it was flooded during high-water stages. Later the present tunnel was driven above high-water mark. About two years ago this mine passed into the hands of the Alaskan Commercial Company, and was worked by them under the management of W. E. Williams up to the middle of the summer of 1902, when it was abandoned on account of the difficulty caused by rolls in the floor of the coal bed. The development and equipment consist of the two tunnels mentioned

[a] Schrader, F. C., Preliminary report on a reconnaissance along Chandlar and Koyukuk rivers, Alaska, in 1899: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 485.

above, a powder house, and an office building at the mouth of the mine. No bunkers were used. The coal was piled on the river beach at the mouth of the mine and loaded on steamboats and barges with wheelbarrows. During one season the high water which comes at the breaking up of the ice is reported to have carried away a large amount of coal mined during the winter. The dwellings and other buildings of the miners were of a temporary nature, and have nearly all been removed with the abandonment of the mine. These buildings were located about one-fourth of a mile up the river from the mine. The main gangway has a length of 600 feet. Above this nearly all the coal available in the present state of development of the mine has been taken out.

Nulato coal bed.—Between the Pickart mine and Nulato it is reported that attempts have been made to open coal beds in several places,[a] only one of which was examined by the writer. This seam is about a mile above the village of Nulato, and is contained in sandstones carrying fragmentary fossil leaves. The sandstone strikes N. 10° E. and dips 40° NW., and about 1 mile to the southwest there are marine beds probably overlying it, from which a few fossils were collected, which seem to be of the same age as the marine beds stratigraphically below the Pickart coal. The stratigraphic section between this coal bed and the marine sandstone has not been minutely examined. If there are no faults or unexposed folds between these points, this coal bed is of Upper Cretaceous age. As far as the writer could determine, the marine sandstone rests on the fresh-water leaf- and coal-bearing beds. These observations are in accordance with those of Dr. Dall,[b] who spent the winter of 1865–66 at Nulato, and thus had opportunity to study the section in detail. The coal seam is contained between sandstone floor and roof, and has a thickness of 2½ feet. The seam contains only about 6 inches of clean coal, the rest being made up of bone coal and some clay partings. No analysis of coal from this bed has been made. The writer saw some of the coal from the more impure part of the bed in use in a blacksmith's forge at Nulato. Except for the high percentage of ash, the coal seemed to be of good quality, comparing well with the coals along the Yukon.

Bush mine.—This mine is situated on the right bank of the Yukon 4 miles below Nulato. The mine opens on the slough behind the first island below Nulato. At this place there is a small bench about 50 feet high, which has probably been formed by a slide from the main hill. Back of the bench is a well-marked escarpment, rising to a flat-topped hill about 30 feet above. When the locality was visited the

[a] Schrader, F. C., Reconnaissance along Chandlar and Koyukuk rivers, Alaska, in 1899: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 485.

[b] Dall, W. H., and Harris, G. D., Correlation papers, Neocene: Bull. U. S. Geol. Survey No. 84, 1892, p. 247.

development consisted of a tunnel about 30 feet long driven into this slide.

The coal is contained in sandstones carrying fossil leaves determined as Upper Cretaceous. The coal was broken and very much weathered, so that it was difficult to obtain any large pieces which did not crumble to fine dirt on exposure to the air. It was impossible to determine the thickness of the bed, although the crushed material was often over 4 feet in thickness. A sample of the coal from the end of the tunnel yielded the following analysis:

Analysis of coal (sample No. 254) from Bush mine, 4 miles below Nulato.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	11.17
Volatile combustible matter	29.48
Fixed carbon	52.02
Ash	7.33
	100.00
Sulphur	.44
Fuel ratio	1.76

Coke, noncoherent.

A blacksmith at Nulato, who was attempting to use this coal for welding, reported that it was inferior to the coal from the prospect a mile above Nulato, or from the Blatchford mine, 9 miles below. This inferior quality is no doubt in part due to the weathered condition of the coal.

The owners of this prospect reported to the writer that they had contracted to deliver 400 tons of this coal on the river bank for use by river steamers next summer. The coal will be mined and sledded over the ice to a suitable landing on the main channel of the river.

Blatchford[a] *coal mine.*—This mine is located on the right bank of the Yukon 9 miles below Nulato. The Yukon banks are low for about 2 miles above the mine, where the flats are extended up a small creek. Below the mouth of this creek a cliff of Pleistocene silt 50 feet high extends along the river for about a quarter of a mile, below which sandstone cliffs rise to a height of about 100 feet.

The coal bed of the Blatchford mine outcrops at the water's edge, near the upper end of this sandstone bluff. The strike throws the outcrop of the seams below the silt cliffs on the one hand and below the river bed on the other, and no other exposure of it is known.

The sandstones at the Blatchford mine dip to the northwest at a high angle. Immediately above the coal bed they are dark and shaly, containing rather abundant fossil plants, which are probably Upper Cretaceous, and above these shaly sandstones are hard gray sandstones,

[a] This name is also sometimes spelled Blatsford. The writer does not know which spelling is correct.

forming the greater part of the cliff. In this sandstone there is considerable evidence of crushing and shearing along bedding planes. Two small seams of coal, which vary in thickness, but nowhere exceed 6 inches, occur in this harder sandstone. The variation in thickness is probably due to shearing.

The one coal seam which has here been worked outcrops below water level. When the locality was examined the opening to workings was under water and the coal was not seen in place. On the river bank, above high-water mark, there was a large pile of coal, mined last winter, but not yet used by steamers on account of the poor landing. This coal is very much crushed, so that from a pile of several hundred tons no large pieces could be obtained. The coal seam is reported to be irregular. Large masses, 8 feet in diameter, have been found and quickly mined out. Its irregularity is believed by the writer to be due to the shearing of the inclosing sandstones along the coal bed.

This coal has been pronounced by some engineers of river steamers to be the best on the Yukon. In the blacksmith's forge it gives good satisfaction. A sample for analysis was taken from a pile containing 40 to 50 tons mined during the winter.

Analyses of coal (sample No. 258) from Blatchford mine, 9 miles below Nulato.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	1.36
Volatile combustible matter	22.44
Fixed carbon	73.98
Ash	2.22
	100.00
Sulphur	.52
Fuel ratio	3.30

It will be seen from this analysis that the coal is a high-grade bituminous, approaching semibituminous. The fuel ratio, 3.3, and the low percentage of water and ash make it by proximate analysis the best coal seen by the writer on the Yukon.

In 1866 Dall examined a coal cropping below Nulato in this immediate vicinity, if not this identical bed. His description is as follows:

About 7 miles from Nulato, on the south side of a level space or flat, a small bluff appears, at the extreme end of which the sandstones are nearly vertical. Here, between two contorted layers of shaly rock, a small coal seam was examined in December, 1866. It has been squeezed out above and below, forming a mere pocket about 2 feet thick and not over 20 feet long on the exposed face. The shales contained obscure vegetable remains, but were much altered, probably by the heat evolved at the time they were folded. The average dip is north 45°. The coal is good, but there are apparently only a few tons of it. The shales are conformable with the brown sandstone, which, however, is a marine formation in which this deposit of lignite is a very exceptional incident.[a]

[a] Bull. U. S. Geol. Survey No. 84, 1892, p. 247.

The Blatchford mine has no visible development or equipment. The workings lie below the level of the river, and the opening is covered with water during the summer months. The coal that has been mined has been taken after the river was frozen. The ice filling the upper part of the workings is first mined out, after which the coal is reached. The excavations probably do not exceed 40 feet in depth. The "mine" is controlled by some employees of the Northern Commercial Company. It is leased, usually for the season, by one or two miners, who are satisfied if they can produce 100 tons of coal during the winter. Probably not over 300 tons have been mined since this coal was discovered.

Williams mine.—This mine is located on the right bank of the Yukon 50 miles below Kaltag and about 100 miles below Nulato. About 5 miles above the mine the river, after dividing into a number of channels, comes together at the foot of a series of bluffs, chiefly of sandstone, but also containing conglomeratic and shaly beds, which extend approximately north and south and continue for a mile below the coal mine. The sandstone bluffs rise from the river to an elevation of 150 feet, which elevation extends back from the river to the limit of vision.

The sandstones in which the coal occurs carry fossil plants, which have been determined as Eocene (Kenai), and show the coal to be undoubtedly younger than the coal beds near Nulato. A mile or more above the mine there is an abundant fresh-water fauna in some of the sandstone beds. Some evidence of faulting appears in the bluffs about one-half mile above the coal mine and renders it difficult to estimate the thickness of the section. A study of the exposures indicates that the coal bed is overlain by at least 2,000 feet of sandstones, conglomerates, and black shales. At the coal bed the strike is N. 70° W. and the dip is 45° N. At the upper end of the bluffs the strike is about N. 30° W. and the dip is variable, but less than at the mine.

One coal bed of workable thickness has been found at this place, but below this bed there are probably other seams of possible commercial importance. The coal seam which is being worked has a thickness of 39 inches and is divided into two nearly equal benches by a clay parting about three-fourths of an inch thick. The quality of the coal in the two benches is very similar. In the upper bench the coal appears dry and carries streaks of "mineral charcoal." In the bottom of the lower bench a small amount of fossil resin, or amber, occurs.

This bed has been followed 400 feet into the hill by the mine workings, and shows no variation in strike or thickness.

Samples of the coal from the upper and lower benches were analyzed, with the following results:

Analyses of coals (samples Nos. 283 and 284) from Williams mine.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Upper bench.	Lower bench.
	Per cent.	*Per cent.*
Water	7.17	6.15
Volatile combustible matter	33.05	40.46
Fixed carbon	51.15	49.86
Ash	8.63	3.53
	100.00	100.00
Sulphur	.40	.53
Fuel ratio	1.54	1.23

Coke, noncoherent.

The analysis shows the coal to be bituminous. Since the coal mined is all from near the croppings and subject to surface influences, it varies very greatly in quality as it is supplied at the mouth of the mine. Probably much coal of an inferior quality has been sold. However, the coal has generally given satisfaction for steaming purposes, and the entire product of the mine has found a ready sale to the river steamers.

This mine was first opened up as the Thein mine,[a] and in 1900 produced some coal. Early in 1902 it passed into the hands of the present owners, and is being developed by Mr. W. E. Williams. In all, about 1,700 tons of coal have been produced.

The development consists of a drift 400 feet long in the river bank above high water. The greater part of the available coal has been stoped out above this tunnel. The coal cars bring the coal to the mouth of the mine, where it is piled up on the river bank to be loaded on the steamers with wheelbarrows, as no bunkers have as yet been built. The other buildings, such as mess house, office, etc., are of a temporary nature. Pls. V, *B* and VI, *A* show the appliances at the mouth of this mine and the method of loading the fuel on steamers. About fifteen men in all are employed during the summer season, while the mine is in operation. These miners are mostly men who have had some experience in the coal mines of the State of Washington. Should the demand for coal warrant it, a slope will probably be driven to lower levels and a hoisting and pumping plant be provided. With such an equipment this mine could no doubt supply all the demand for coal on this part of the Yukon for many years to come.

[a] Coal Resources of Alaska, p. 556.

A. BARGE LOADING COAL AT WILLIAMS MINE.

B. NULATO, INDIAN VILLAGE, SHOWING WOOD PILES ON RIVER BEACH.

Coal mine No. 1.—This mine is situated on the right bank of the Yukon 25 miles below the Williams mine. Above and below this place for several miles there are sandstone bluffs rising about 50 feet above the river. At the coal mine the bluffs recede and a bench about 50 feet high appears between them and the river. The opening to the coal mine is located on this bench.

The sandstones containing this coal also carry fossil plants, but the collection made was too meager to permit determination of their age.

These beds strike N. 60° W., and at the coal mine dip 35° SW. About 1 mile above this place the sandstones have the same strike, but dip to the northeast at an angle of 25°, indicating an anticlinal structure, with the coal bed exposed on the southwestern limb.

The coal seam has a thickness of from 2½ to 3 feet. The following analysis of a sample taken from the croppings of this vein near the old entrance to the mine indicates a good quality of bituminous coal. The croppings where the sample was obtained were exposed to the sun, and in all probability the amount of water in freshly mined coal would be somewhat greater than this analysis shows:

Analysis of coal (sample No. 288) from coal mine No. 1, 80 miles below Kaltag.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	4.82
Volatile combustible matter	34.62
Fixed carbon	55.65
Ash	4.91
	100.00
Sulphur	0.21
Fuel ratio	1.61

Coke sinters slightly.

The Alaskan Commercial Company attempted to open a coal mine here in the winter of 1898. W. E. Williams was manager of these operations, and 900 tons were produced, but the mine was abandoned the same year on account of the difficulty of keeping out water. The mine buildings still left include one frame building and two cabins. The workings included a 9 by 7 foot slope tunnel, which at the time of the writer's visit was full of water.

Halls Rapids.—These so-called rapids, which are merely a slight acceleration of the sluggish current of the Yukon, are about 50 miles above Anvik. There a series of bluffs composed of white and yellowish tuffs, containing some impure lignite seams, extends along the right bank of the Yukon. Some of these lignite beds have been opened by shallow prospect tunnels. About one-half mile below the so-called rapids a seam of coal about 6 inches thick was seen in this tuff. This cropping has been traced several hundred feet, but the bed is probably not very extensive. The coal has a compact, lignitic appearance and

a conchoidal fracture. The analysis indicates a fuel of good quality, but the coal is not believed to have any economic value because of its limited extent.

Anvik River.—Mr. J. W. Chapman, missionary at Anvik, reported to the writer the occurrence of coal on Anvik River about 50 miles above its mouth. This point is probably about 10 miles back from the Yukon, and in a general way west of the sandstone bluffs in which the Williams mine coals occur, and probably represents a western extension of the same field. No attempt has been made to open this coal, but it finds a limited use among the natives in their manufacture of black paint.

CLASSIFICATION OF YUKON COALS.

The coals of the Yukon Basin occur in sandstones of Tertiary and Cretaceous age and present great variations in quality, due probably in part to primary differences in composition and in part to metamorphic influences which have acted more or less locally. They range from high-grade lignites to semibituminous coals.

In the classification of the Yukon coals some uncertainty and confusion arise from the distinction to be made between lignites and bituminous coals. The same confusion prevails in regard to the coals of western United States.[a]

The geologists who first studied the coal fields of the Rocky Mountain region, finding that the coals were contained in rocks younger than the Carboniferous, classed as lignites all of the post-Paleozoic coals. The same classification, based on stratigraphic position rather than character of the coal, has been carried to Alaska, and many coals shown by their analyses to be bituminous have been classed as lignites.[b] The table of analyses on page 61 shows that many of the Yukon coals compare favorably with coals classed as bituminous in eastern United States.

The fuel value of coal is to a certain extent indicated by the fuel ratio.[c] This varies from less than 1 in lignites and some cannel coals to more than 20 in some anthracites. In lignites, as the fuel ratio decreases the percentage of water increases. In general,[d] it may be

[a] Knight, Wilbur C., Coals and coal measures of Wyoming: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 4, 1895, pp. 208-215. Hills, R. C., Coal fields of Colorado: Mineral Resources U. S. for 1892, U. S. Geol. Survey, 1893, pp. 319-365. Taff, J. A., Preliminary report on Camden coal field of southwestern Arkansas: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 313-329. Taff and Adams, Geology of eastern Choctaw coal field, Indian Territory: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 257-311. Storrs, L. S., The Rocky Mountain coal fields: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 422-471. Hayes, C. W., Coal fields of the United States: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 19.

[b] Dall, W. H., Report on coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 763-908. Brooks, Alfred H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 515-571. Summary Report Geol. Survey of Canada, 1901, pp. 46-48.

[c] The fuel ratio is the quotient obtained by dividing the percentage of fixed carbon by the percentage of volatile combustible matter.

[d] Hayes, C. W., Coal fields of the United States: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 19.

stated that an anthracite has a fuel ratio above 10 and a bituminous coal has a fuel ratio between 1 and 5. There are two grades between the bituminous and the anthracite: Semianthracite, with a fuel ratio from about 7 to 10; and semibituminous, with a fuel ratio from 5 to 7. Cannel is a variety of bituminous coal which is characterized by a low fuel ratio, often less than 1.

In distinguishing between the lignite and bituminous grades of coal the problem is more complex, and three elements must be considered: First, fuel ratio; second, content of water; and third, physical character of the coal, as shown by the presence or absence of woody structure. Dr. Hayes has suggested to the writer that a lignite may be distinguished from a bituminous coal by its having a water content above 10 per cent and a fuel ratio less than 1.[a] The relation of the two elements can be expressed by the quotient of the water content divided by the fuel ratio. This might well be called the lignite ratio, and is above 10 for a lignite and less than 10 for a bituminous coal. By the use of this ratio, the physical character of the coal being neglected, it is found that nearly all the coals that have been classed as lignites by physical character alone fall readily into that class, while the bituminous coals are as certainly distinguished.

As there is no definite dividing line between bituminous and anthracite, so the variation from lignite to bituminous is gradual, and an intermediate division or grade is often required between the typical lignite, with a water content above 15 per cent and a fuel ratio not above 0.5, and the typical bituminous coal, with a fuel ratio near 1.5 and a water content under 7 per cent. If the above-mentioned lignite ratio be accepted as the basis of separation, it will be seen that typical lignites and typical bituminous coals can be recognized from their analyses by inspection. It is only in doubtful cases that the lignite ratio is required to determine the grade of the coal. The writer would suggest that, where a definite classification is required, doubtful cases in which the lignite ratio falls between 9 and 11 should be classed as intermediate between the lignites and the bituminous coals.

In the grades of coal between bituminous and anthracite the terms semibituminous and semianthracite are both made use of as trade names in the United States. A logical classification and nomenclature would require a similar use of the terms semilignite and semibituminous for the grades of coal between lignite and bituminous. Such use seems to have been made of the term semibituminous in the coal fields of the Rocky Mountain region.[b]

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[a] The same statement is made by J. A. Taff, Preliminary report on the Camden coal field of Arkansas: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 326.

[b] Storrs, S. L., Rocky Mountain coal fields: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 424. Hills, R. C., Coal fields of Colorado: Mineral Resources U. S. for 1892, U. S. Geol. Survey, 1893, pp. 319-365. Knight, W. C., Coal fields of Wyoming: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 4, 1895, pp. 208-215.

To avoid confusion with the usages in the eastern coal fields of the United States, the writer in the following classification has made use of the term lignitic coal for those grades which by approximate analysis fall between typical lignite and typical bituminous. The lignitic coals of the following table are coals in which the quotient of the fuel ratio divided by the percentage of water falls between 9 and 11 in value.

In the following table of analyses (p. 61) of coals from the Yukon Basin many heretofore published analyses have been added to those made for the writer from samples collected the past season. The authority for these old analyses is given. The samples collected by the writer and analyzed by Dr. E. T. Allen, of the United States Geological Survey, were treated as follows: On being collected they were placed as soon as possible in tin cans, with tight-fitting covers, to prevent escape of moisture. The samples, however, were collected under extremely varying conditions, some being taken from the breasts and faces of the mines, some from mine dumps and from piles of coal already delivered to the consumer, and some from surface croppings of undeveloped coal beds. On their arrival in the laboratory it was found that the amount of moisture contained in the cans with the samples varied greatly, depending on the condition of the samples when collected, whether from wet or dry places in the mines, or, if from mine dumps, whether taken on rainy or fair days. To secure uniform conditions the samples for analyses were spread on a table in a vacant room, of which the outside windows were open, and left exposed to the air for about twenty-four hours. They were then crushed and prepared for analysis in the ordinary way.

In the second table a comparison is made between the Yukon River coals and some from Washington and British Columbia.

Table of proximate analyses of coals from the Yukon Basin, arranged in geographic sequence, proceeding down the river.

Locality.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Fuel ratio.	Character of carbon residue.	Character of coal.	
Lewes River, 5½ miles above Rink Rapid [a b]	6.03	36.92	49.03	8.02	.....	1.33	.....	Bituminous.	
Five Fingers mine [c]	3.58	41.05	43.11	12.26	0.38	1.05	Slightly coherent	Do.	
Coal Creek (Klondike River), upper seam [a d]	18.31	34.96	40.88	5.85	.....	1.17	"Coking"	Lignite	Circle province.
Coal Creek (Klondike River), lower seam [a d]	19.37	33.85	37.45	9.33	.....	1.11	.....	do	
Coal Creek (Yukon River), middle of, 5-foot bed. [c]	12.57	39.54	41.98	5.91	.....	1.06	Slightly coherent	do	
Coal Creek (Yukon River), bottom of, 5-foot bed. [c]	10.58	38.42	31.54	19.96	.80	.82	do	do	
Cliff Creek, upper working, Yukon River [a e]	8.57	42.04	45.77	3.62	.....	1.08	"Coking"	Bituminous (?)	
Cliff Creek, lower working, Yukon River [a e]	10.58	40.10	46.74	2.58	.....	1.16	.....	Lignitic	
Cliff Creek, Yukon River [a f]	18.0	44.3	33.6	3.1	.82	.75	.....	Lignite	
Do. [a f]	16.0	35.5	38.5	10.0	Trace.	1.08	.....	do	
Do. [a f]	16.6	42.9	25.5	15.0	.....	.59	.....	do	
Do. [a f]	12.5	37.5	34.6	15.4	.....	.92	.....	do	
Do. [a f]	9.98	44.08	40.99	4.95	2.37	.93	.....	Lignitic	
Cliff Creek, lower workings [c]	10.71	41.33	45.33	2.63	1.06	1.10	Slightly coherent	do	

[a] Brooks, Alfred H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 565.
[b] Dawson, George M., Exploration in the Yukon District and British Columbia: Geol. Survey Canada, 1887–88, new series, vol. 3, pt. 1, p. 149 B. Analysis by G. C. Hoffmann, Geol. Survey Canada.
[c] Samples collected by Arthur J. Collier. Analysis by E. T. Allen.
[d] McConnell: op. cit., p. 46. Analysis by Geol. Survey Canada.
[e] McConnell, R. G., Summary Report for 1901, Geol. Survey Canada, p. 48. Analysis by Geol. Survey Canada.
[f] North American Trading and Transportation Company.

Table of proximate analyses of coals from the Yukon Basin, arranged in geographic sequence, proceeding down the river—Continued.

Locality.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Fuel ratio.	Character of carbon residue.	Character of coal.	
Small creek emptying into Yukon below Coal Creek.[a b]	6.24	43.94	47.74	2.08	.....	1.08	.....	Bituminous	Circle province.
American Creek, Yukon River[a c]	6.75	39.13	37.59	16.53	3.40	.96	"Noncoking"	Bituminous (?)	
Nation River mine, Yukon River[d]	1.39	40.02	55.55	3.04	2.98	1.39	Firmly coherent[e]	Bituminous	
Washington Creek, 10 miles from Yukon[d]	13.48	43.74	39.68	3.20	.24	.91	Not coherent	Lignite	
Washington Creek, 12 miles from Yukon[d]	11.13	42.58	44.20	2.10	.26	1.04	do	Lignitic	
Miller's mine, nearly opposite mouth of Hess Creek, Yukon River.[a b]	7.29	37.38	36.91	18.42	.....	.98	.....	Bituminous (?)	Rampart province.
Drew mine, 13-inch bench[d]	9.58	36.87	39.83	13.72	.33	1.08	Not coherent	Lignitic	
Drew mine, 25-inch bench[d]	9.54	40.09	37.35	13.02	.....	.93	do	do	
Drew mine, lower bed[d]	14.44	47.15	33.77	4.64	.....	.72	do	Lignite	
Minook Creek, 2 miles from Yukon River[d]	11.21	44.32	38.64	5.83	.....	.87	do	do	
Yukon River, 2 miles below Rampart[d]	16.43	41.09	53.22	7.26	.....	.86	do	do	
Cantwell River, below Rampart[f]	13.02	48.81	32.40	5.77	.16	.66	do	do	
Nahoclatilten, 55 miles above Nulato[d]	6.88	41.82	48.93	2.37	.65	1.17	Slightly coherent	Bituminous	Nulato province.
Upper Koyukuk[a g]	4.47	34.32	48.26	12.95	.....	1.40	"Noncoking"	do	
Twelve miles above Nulato on the Yukon[a g]	0.86	25.75	66.51	6.88	.....	2.22	"Coking"[e]	do	
Pickart mine, 200 feet from entrance[d]	1.02	27.33	65.03	6.62	.56	2.37	Compactly coherent[e]	do	
Pickart mine, 600 feet from entrance[d]	1.64	24.98	58.18	15.20	.....	2.32	do.[e]	do	
Small coal bed above Pickart mine[d]	2.22	24.76	50.38	22.64	.56	2.03	Slightly coherent	do	
Bush coal, 4 miles below Nulato[d]	11.17	29.48	52.02	7.33	.44	1.76	Not coherent	do	
Blatchford mine, 9 miles below Nulato[d]	1.36	22.44	73.98	2.22	.52	3.29	Slightly coherent	do	
Williams mine, upper bench[d]	6.15	46.46	49.86	3.53	.53	1.22	Not coherent	do	

Williams mine, lower bench[d]	7.17	33.05	51.15	8.63	.40	1.52	do	do
Coal mine No. 1[d]	4.82	34.62	55.65	4.91	.21	1.60	Slightly coherent	do
Halls Rapids[d]	8.23	37.88	51.08	2.81	.42	1.35	Not coherent	do

[a] Brooks, Alfred H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 565.
[b] Spurr, J. E., Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 382. Analysis by H. N. Stokes, U. S. Geol. Survey.
[c] Barnard, E. C., Maps and descriptions of Alaska, U. S. Geol. Survey, 1898, p. 81. Analysis by U. S. Geol. Survey.
[d] Samples collected by Arthur J. Collier. Analysis by E. T. Allen.
[e] Will probably make a coke of commercial value.
[f] Samples collected by Alfred H. Brooks. Analysis by E. T. Allen.
[g] Schrader, F. C., Reconnaissance along Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 485–486. Analysis (not published) by George Steiger, U. S. Geol. Survey.

Comparison of average analyses of coals from Yukon River, southern Alaska, British Columbia, and Pacific coast.

	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Fuel ratio.
Average composition of 9 Yukon River lignites	11.89	41.11	40.82	6.20	0.89
Average composition of 9 Yukon River bituminous coals	4.69	32.05	55.89	6.97	1.85
Average composition of 5 Cook Inlet lignites [a]	11.59	49.03	31.64	7.73	0.64
Average composition of 4 Alaska Peninsula coals [a]	2.05	39.23	49.92	8.77	1.27
Composition of Lisburne coal [b]	3.75	43.75	47.39	5.11	1.08
Average composition of 3 coals from vicinity of Controller Bay [a]	.76	13.42	81.68	4.12	6.06
Average composition of 15 Vancouver Island coals, chiefly from Nanaimo and Comax [a]	.....	30.33	60.23	9.44	1.98
Average composition of 10 standard coals from the State of Washington [c]	4.43	31.60	56.01	7.45	1.77

[a] Brooks, A. H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 552.

[b] Ibid., p. 566.

[c] Smith, G. O., Coal fields of the Pacific coast: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 490.

SUMMARY.

CHARACTER AND VALUE OF YUKON COALS.

The coals that have been mined in the Yukon Basin are high-grade lignites and rather low-grade bituminous coals. With the exception of that at Nation River all the coals examined in the Circle and Rampart provinces are lignites, or at least lignitic, those of the Circle province probably being of a little higher grade than those of the Rampart province. All the coals examined in the Nulato province fall within the bituminous grade.

In the Circle province the best coal by proximate analysis is that mined a few years ago at Nation River. This is a bituminous coal rich in hydrocarbons and having a low percentage of water and ash. Its percentage of sulphur, however, is higher than that of any other coal examined by the writer, and the supply is limited and uncertain. Some rather low-grade bituminous coal, with a high percentage of ash, has been mined at the Five Finger mine, on Lewes River, 200 miles above Dawson and beyond the limits of the Circle province. The main coal supply of this province, however, is to be found in the lignite-bearing areas. At Cliff Creek, in Canadian territory, these lignites have been developed and yield an abundant supply of coal which gives good satisfaction for steaming purposes. The limits of

this coal field have not been determined, but there are probably between 50 and 100 square miles of coal land contiguous to this mine, the greater part of which lies some distance from the Yukon.

In American territory, on Washington Creek, about 12 miles from the Yukon, there is another large field, which will probably yield a considerable supply. This coal is a lignite, and is, so far as the analyses show, of slightly lower grade than that at Cliff Creek.

In the Rampart province the coal field of the Drew mine is the only one which has immediate value, and it is of very limited extent, the area of coal-bearing rocks probably not exceeding 4 square miles. The coal is a lignite, containing higher percentages of water and ash than the standard coals of the Circle province.

In the Nulato province coal has been exploited at a number of localities in the coal-bearing rocks which extend along the Yukon for 200 miles. The coal beds are usually rather thin, none of them measuring over 4 feet, and some of the seams are so crushed by shearing faults of the inclosing strata that systematic mining is difficult. At Williams mine, 90 miles below Nulato, in this belt, the coal bed is regular and holds a uniform thickness as far as development has gone. The conditions are favorable for producing a large amount of coal. With proper development the mine can probably supply all the coal that will be required on this part of the Yukon for many years. The coal here is bituminous, having a fuel ratio of from 1.2 to 1.5 and a water content below 7.5 per cent.

Coal of a better grade is found at the Pickart mine and at the Blatchford mine, also in this province, but the beds are faulted and the conditions for producing coal are not favorable. At the latter mine the coal is by proximate analysis the best found by the writer on Yukon River, having a fuel ratio of 3.3, water content below 2 per cent, and ash below 3 per cent.

Many steamboat men prefer the lignitic coal from Cliff Creek mine to the coals from the vicinity of Nulato. This is probably to be accounted for in part by the character of the grates on which it is burned, since the Cliff Creek coal burns more freely and produces heat more quickly than do the coals of the lower river.

The lignites of the Circle and Rampart provinces are contained in sandstones of Eocene age, correlated with the Kenai series. The bituminous (Nation River) coal of the Circle province is probably of Permian age, while the bituminous coals of the Nulato province are contained in a series of sandstones in part Upper Cretaceous and in part Eocene in age, which has not yet been separated on stratigraphic or lithologic grounds. The Pickart and Blatchford coals are Upper Cretaceous, while the Williams coal is Eocene, in age.

PRESENT DEVELOPMENT AND METHODS OF MINING.

In 1866 Dall examined a bed of coal 7 miles below Nulato, but up to the time of the discovery of gold on Klondike River, in 1897, little was done toward opening coal mines on the Yukon. With this discovery and the consequent influx of people, the Cliff Creek mine, in Canadian territory, and the Nation River, Drew, Pickart, Blatchford, and Whelp & Thein (Williams) mines, and Coal mine No. 1, were opened up, and have supplied a limited amount of coal, both for steaming on the Yukon and for domestic purposes at Dawson.

The methods of mining coal heretofore employed have been most primitive, and the workings of very limited extent, largely because the demand for coal is supplied by small amounts delivered on the river bank during the months from June to September, inclusive. Timber is convenient, and ventilation is easily obtained by air shafts to the surface, for in this climate there is always a great difference in temperature between the air in the mine and that outside. No trouble with gas has yet been experienced, and safety lamps have not been required. This may be accounted for by the fact that the workings have not penetrated beyond the zone of perpetual frost. Care must be exercised with the lignites of the Circle and Rampart provinces to prevent spontaneous combustion after the coal is mined. Instances are reported where the beds have been on fire, but none came under the observation of the writer. With the exception of the Drew mine, near Rampart, none of the mines along the Yukon, in American territory, are equipped with bunkers or other conveniences for loading the coal on steamers. The coal is piled on the river bank and loaded with wheelbarrows. Most of the mines are so situated that mine cars convey the coal directly to the river's edge at the mine's mouth. At Nation River the coal was mined about 1½ miles from the river and sledded over the snow in winter to the landing. On Washington Creek a similar plan is proposed until a railroad can be built. At Cliff Creek, the North American Transportation and Trading Company's mine, there is a narrow-gage railroad from the river bank to the mine, a distance of 2½ miles. At the Blatchford mine, 9 miles below Nulato, the coal is mined in the winter, for the opening to the mine is below the water at ordinary stages of the river, and during the summer months the mine is flooded. After the freeze-up the ice is mined out before the coal is reached. The coal from the mine must be sledded to ground above the high waters that occur on the breaking of the ice in the spring.

Since the Yukon coal beds have been worked only for the last five years, and then in a desultory way, the whole amount of coal produced in American territory has not been great, probably not exceed-

ing 9,000 tons, which has been sold at from $10 to $20 a ton. Probably the average price paid for such coal has not been far from $14 a ton, representing a value of about $76,000.

FUTURE DEVELOPMENT.

The coal mined on the Yukon has been burned principally on river boats for steaming purposes. A smaller amount has been consumed for domestic purposes at Dawson and other points along the Yukon. The coal has been used in competition with wood cut along the river, and as the supply of wood becomes exhausted the demand for coal will naturally increase. There is, however, sufficient timber conveniently accessible along the Yukon to supply wood to meet the present demands for some years to come. The important advantage of coal over wood for steaming purposes consists in its more compact form, so that a greater amount of fuel can be taken on at one time. It is also loaded more quickly than wood, even by the primitive methods in vogue at the present time. At Dawson coal from the Five Finger mine or from Cliff Creek is worth from $15 to $20 a ton. The Electric Lighting Company had contracted for 1,500 tons of the former coal at $15. Wood sells at about $10 a cord at Dawson. Coal delivered at the river bank from the Yukon mines brings from $10 to $12 a ton. Cord wood varies very greatly in price, but probable averages about $8 a cord.

During the summer of 1902 coal could be obtained at only two points on the Yukon below Dawson. These points were nearly 1,000 miles apart, and there were no conveniences for loading at either of them. With the development of the oil fields in southern California and the consequent cheapening of crude oil as a fuel, some of the companies operating steamers have begun making arrangements to use this oil for steaming purposes on the Yukon. Should the use of oil prove practicable, it will retard the development of the Yukon coal mines. The oil can probably be purchased and transported to depots along the Yukon at an expense little, if any, greater than the cost of coal or wood at present prices. After these depots are established from three to four hours daily will be saved, which, under the present arrangement, is spent in taking on wood or coal. Since oil can readily be made to flow on board from the oil tanks, and as the oil burners are self-feeding, the services of a large force of deck hands and firemen will be dispensed with.

The coal beds of the Yukon will probably never supply coal for exportation, because of their limited extent, the character of the coal, the cost of mining, and the distance from a market, but with proper development they will probably be sufficient to supply all local demands that are at present foreseen.

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PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 218.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

The Bulletins, Professional Papers, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports. This bulletin is the twenty-sixth in Series A, the complete list of which follows. (B = Bulletin, PP = Professional Paper.)

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B 46. Nature and origin of deposits of phosphate of lime, by R. A. F. Penrose, jr., with introduction by N. S. Shaler. 1888. 143 pp. (Out of stock.)

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PP 15. The mineral resources of the Mount Wrangell district, Alaska, by W. C. Mendenhall and F. C. Schrader. 1903. 71 pp., 10 pls.

B 218. Coal resources of the Yukon, Alaska, by A. J. Collier. 1903. 71 pp., 6 pls.

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DECEMBER, 1903.

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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

THE

ORE DEPOSITS OF TONOPAH, NEVADA

(PRELIMINARY REPORT)

BY

J. E. SPURR

WASHINGTON
GOVERNMENT PRINTING OFFICE
1903

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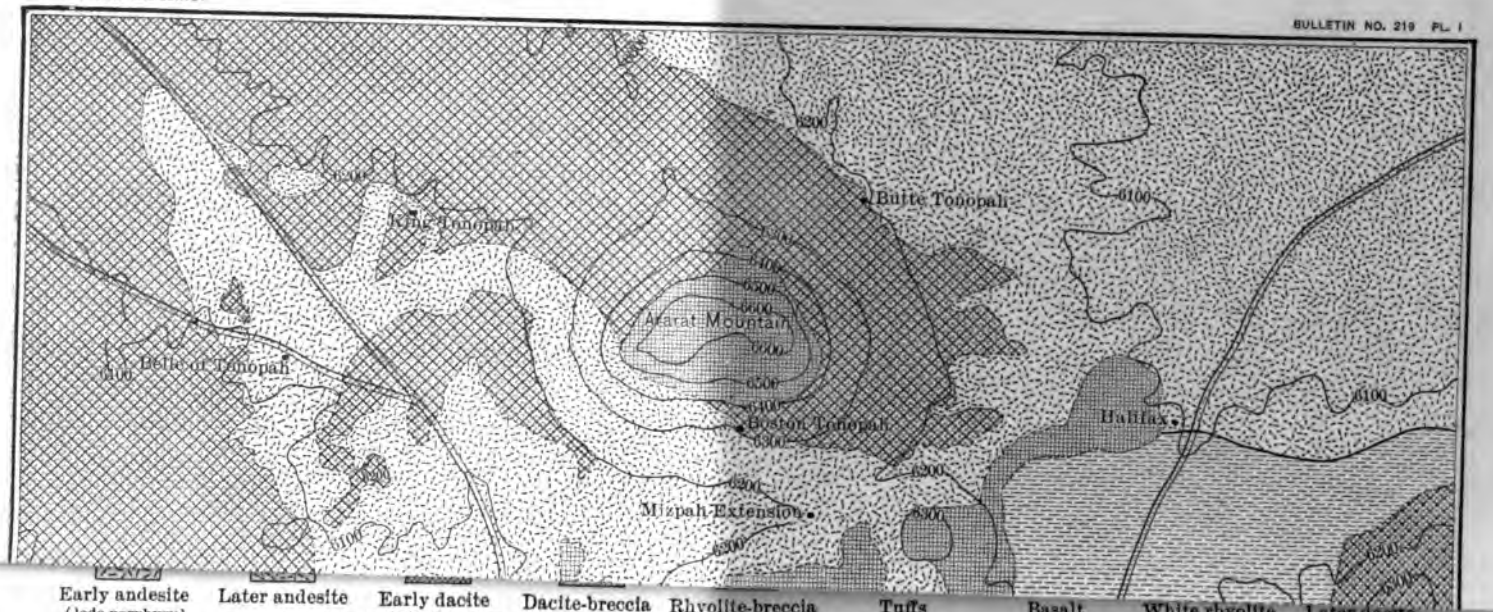


GEOLOGIC MAP OF TONOPAH MINING DISTRICT.

ORE DEPOSITS OF TONOPAH, NEVADA.[a]

By J. E. SPURR.

LOCATION, CLIMATE, AND POPULATION.

Tonopah is situated in Nye County, Nev., near the Esmeralda County line. It lies south of Belmont, and about 60 miles east of Sodaville, which is on the Carson and Colorado Railroad. The camp is reached by semidaily stage from the latter point.

The climate is arid, with rare rains and occasional snows. The present water supply is pumped from wells in a water zone some 4 miles north of the town.

At the present writing the camp has an estimated population of 5,000. It has electric lights, waterworks, two newspapers, and has attracted enterprising men from all parts of the country.

DISCOVERY AND DEVELOPMENT.

Tonopah was discovered in 1900 by J. L. Butler, who was on a prospecting trip. He gave his samples to Mr. T. L. Oddie, of Belmont, who had them assayed for him. These samples showed values of from $50 to $600 to the ton. Mr. Butler gave T. L. Oddie, W. Brougher, and several others interests in the original eight claims which he located, now the property of the Tonopah Mining Company.

In doing the location work 2 tons of ore was sorted out and shipped to Selby's Smelting Company. This netted about $600, and from that time the property has paid for its own development.

In December, 1900, a few leases were let, and in the spring of 1901 over a hundred more. Before the end of 1901 the lessees are said to have extracted ore to the value of about $4,000,000. In January, 1902, the leases having expired, the Tonopah Mining Company commenced development work, in which it is still engaged.

[a] The writer has spent about five months in field work at Tonopah and four months at Washington studying material collected at Tonopah. A satisfactory final report on the district calls for more detailed office study, microscopic examination of thin sections, chemical investigation, etc., which will now be carried on, and the completed report issued as soon as possible. Since, however, there is an urgent call by the mining public for some immediate information concerning the region, the Director has authorized the writer to issue a preliminary report containing an outline of the results to date.

Following is a table of the weight and value of the ore shipped, taken from smelter returns:[a]

Weight and value of ore shipped to April 1, 1903.

Year.	Weight.	Gold.	Silver.
	Pounds.	*Ounces.*	*Ounces.*
1901	5,067,852	9,780.95	623,487.83
1902	22,836,355	27,003.84	2,408,946.60
1903 (to April 1)	3,481,443	4,212.96	399,186.30
Total	31,385,650	40,997.75	3,431,620.73

Total value, $2,662,401.25.[b]

There are now[c] on the dump close to 25,000 tons of ore, of an average value of $50 per ton.

Subsequently ledges were cut in a number of different localities, such as the Montana Tonopah, Mizpah Extension, California Tonopah, West End, etc. Some of these are low grade, while some show high values. All are in the development stage.

Besides the Mizpah the only mine in the Tonopah district proper which has actually made shipments, so far as the writer is aware, is the Montana Tonopah, where ore was discovered in depth by prospecting under the later andesite capping after the discovery and earlier development of the Mizpah vein. The shipments[d] of the Montana Tonopah to and including July 15 of the present year (1903) are as follows:

Shipments from the Montana Tonopah mine to July 15, 1903.

Shipment.	Pounds.	Total value.
First shipment, May 5:		
First-class ore	29,128	$6,596.39
Second-class ore	23,331	2,472.76
Second shipment, third-class ore for mill test	21,200	749.25
July 15	29,019	4,381.81
	15,664	715.61
Total	118,342	14,915.82

Shipments have been made by both companies since these data were collected.

[a] For this table and the preceding information the writer is indebted to Mr. T. L. Oddie, manager, at Tonopah, of the Tonopah Mining Company.

[b] Estimated by the writer.

[c] May, 1903.

[d] Courtesy of Mr. C. E. Knox, president Montana Tonopah Mining Company.

The values in the ores are entirely gold and silver. The proportion of gold to silver is usually remarkably uniform, and is the same in both the oxidized and the sulphide ores, namely: The gold is to the silver, by weight, as 1:90 or 1:100, making the values about two-sevenths gold and five-sevenths silver. In some of the excessively rich ores the proportion of gold becomes greater, occasionally making up half of the total value.

TOPOGRAPHY.

That the mountain range in which Tonopah is situated is of volcanic origin is shown by its topography. It consists of a series of eroded mesas and detached or connected hills. These mesas and hills are irregularly distributed, with no definite valley systems between. They are separated by patches of sloping or rolling country, largely covered with "wash," or débris worn from the hills. The mesas are the remnants of volcanic flows; the isolated or connected irregular hills are denuded volcanic necks.

An excellent topographic map of the country immediately around Tonopah, on the scale of 800 feet to an inch, has been made by Mr. W. J. Peters, of the United States Geological Survey. On this it is seen that the general elevation of the slight valley-like depression in which the town of Tonopah lies is about 6,000 feet above sea level, while the top of Butler Mountain, which is the highest mountain near the town, is 7,160 feet.

GENERAL GEOLOGICAL HISTORY.

Pre-Tertiary formations.—In the immediate vicinity of Tonopah the rocks are all Tertiary volcanics or sedimentary tuffs belonging to the volcanic period, and composed partly of ash and partly of silt derived from the erosion of the lavas. Eight or nine miles south of the camp, however, there is limestone, very likely of Cambrian or Silurian age, and in this granitic rock is intrusive. Limestones and granites occur also several miles north of Tonopah, and at intervals between there and Belmont. At Belmont the limestone, into which granite is intrusive, is known to be Silurian.

At Tonopah itself occasional limestone fragments and more abundant fragments of a fine, even-grained pegmatite occur in the volcanic breccias. They are blocks which were hurled out from the volcanoes at the time of their eruption. Thus it is shown that at an uncertain depth below the present surface the ascending lavas broke through rocks of this character.

Early andesite eruption.—The oldest rock outcropping in the immediate vicinity of the camp is a hornblende-andesite, or, rather, was such, for no fresh portions have been found and the rock has been altered so as to acquire an aspect in general very different from its original one.

Subsequent to the eruption of this rock fractures were formed in it, and these became the channels for circulating solutions, probably ascending hot waters, closely connected with the volcanism. The waters were remarkable for intensity of action. The rocks which they traversed have been chemically transformed, the chief process being silicification, so that they are now found more or less completely altered to quartz and sericite (fine muscovite). Along fracture zones the rock has been replaced almost entirely by quartz carrying silver and gold, and these constitute the veins by which Tonopah is known. Some parts of the hornblende-andesite, on the other hand, show chiefly calcite and chlorite, with pyrite, as alteration products; but such phases have not yet proved to lie immediately adjacent to important veins, and, as a rule, do not seem to be indicative of the proximity of the best class of ore.

Later andesite eruption.—There is evidence that these events were followed by a considerable period of erosion, long enough to bring the veins to the surface. Then another eruption of andesite occurred. This later andesite, which was abundant in amount, differed from the earlier andesite in containing, as dark minerals, pyroxene and biotite rather than hornblende, and it also differed in some structural and textural points. It is probable that this andesite came up through the hornblende-andesite in places, and also flowed over it, completely covering it and its contained veins.

Rhyolite and dacite eruptions.—Following probably another period of erosion and volcanic rest, eruption was vigorously renewed and there were outbreaks at many closely adjacent points. The lavas were rhyolites and siliceous dacites, closely related to one another. Some vents emitted one, some the other rock. This period of volcanism was long and a number of different lava flows of dacite and rhyolite alternated or mingled. The eruptions were often explosive, as is shown by the considerable quantity of pumiceous and fragmental material in the volcanic breccias of this period.

Lake sediments.—During this volcanic epoch a large fresh-water lake formed, of unknown, but probably great extent. In it were deposited white, finely stratified ash and tuff, and some beds are entirely made up of late Tertiary infusoria. In places the sediments of this lake, exposed near Tonopah, are several hundred feet thick.

It is probable that this lake was partly filled by sediments and then drained by an uplift. Near the top of Siebert Mountain (a white tuff mountain southwest of Mount Brougher) there is what appears to be a river channel belonging to this post-elevation epoch, containing rounded waterworn pebbles of rocks such as now outcrop to the north and east of Tonopah, and fragments of silicified wood, showing the presence of vegetation at that time. This uplift may be ascribed to volcanism, for it was soon followed by renewed outbursts of lava.

Eruption of basalt and intrusion of later dacites and rhyolites.—Above the tuffs on Siebert Mountain is a thin sheet of slaggy basaltic

rock, the first of the upwellings of the next period of volcanic activity. Soon afterwards great columns of dacite and rhyolite made their way to the surface. The eruptions from these vents must have been chiefly explosive, and the products light and scanty and easily swept away, for no trace of them has been found in the immediate vicinity of Tonopah. The volcanic necks, however, have been laid bare by erosion, and on account of their superior hardness to the tuffs and breccias, in which they were intruded, now stand up as low detached mountains. Brougher Mountain, Butler Mountain, Siebert Mountain, and Golden Mountain are all dacite necks of this period, while a group of rhyolite eminences, consisting of Oddie and Ararat mountains and Rushton Hill, represent necks of very nearly the same period as the dacite.

Faulting of the region.—At about this period occurred an event of great scientific and economic interest—the faulting. A considerable number of important and complicated faults have been found in the region. Their age, as denoted by their relations to the different formations, seems nearly uniform. All the rocks up to and including the stratified tuffs have been displaced by the faulting, and on Siebert Mountain the thin sheet of basaltic rock overlying the tuff has been faulted with it. But these faults invariably stop at the contact of the dacite necks, which are not affected, and the same is probably, though less certainly, true of the rhyolite necks above noted. Indeed, the dacite certainly (and the rhyolite less certainly) has been intruded as dikes along the faults.

The geological map (Pl. I) reveals some important points. It shows that the area of observed complicated faulting is in general coextensive with the region of late dacite intrusion. This region, which occupies the southeastern portion of the district, is downsunken in comparison with the unfaulted or little-faulted region on the northwest. Near the dacite necks the observed faults are rather more numerous than elsewhere, and in many instances it may be established that the blocks adjacent to the dacite have been downsunken in reference to blocks farther away. From these intrusive necks the faults run in a roughly radiating fashion and seem to follow no regular system of trend. Detailed study of the contact phenomena of the dacite shows that the minute faults in the tuffs at these points generally have their downthrown side next the dacite. From these facts the following conclusions have been reached. The faulting was chiefly initiated by the intrusion of the massive dacite necks (the rhyolite necks were probably not so bulky). After this intrusion and subsequent eruption there was a collapse and a sinking at the various vents. The still liquid lava sank, dragging downward with it the adjacent blocks of the intruded rock, accentuating the faults, and causing the described phenomena of downfaulting in the vicinity of the dacite. This sinking of volcanic centers after eruption has been well established by students of volcanism.

The economic interest in this faulting lies largely in the circumstance that the veins in the early andesite have been cut and displaced thereby.

Recent erosion.—To complete the geological history, we have to conceive of the considerable period of erosion which stripped from the surface a great thickness of volcanic material, leaving the resistant volcanic necks standing out as hills, and laying bare the present surface. Certain blocks of limited extent had been raised by the faulting above the level of the rest, and here the surface of erosion reached the early andesite and uncovered the rich veins contained in it; and it is the discovery of these veins which has made the subject of the geology of the still covered region of such lively interest to miners.

Sequence of formations and events.—The following, then, is the sequence of events as deciphered for the vicinity of Tonopah:

Sequence of formations and events in the vicinity of Tonopah.

Early andesite.
  Fracturing.
  Vein formation. (Primary minerals, quartz, valencianite, stephanite, pyrite, chalcopyrite?) Values good; gold and silver, silver predominant.
Erosion.
Later andesite.
Probable erosion.
Dacite.
Dacite breccia.
Rhyolite breccias, flows, and dikes, intermingled with slightly stratified or interstratified pumiceous or tuffaceous fragmental material.
  Vein formation. (Primary minerals, quartz, pyrite.) Values relatively low; gold and silver, gold apt to predominate.
Erosion.
Tuffs, with an occasional thin rhyolite flow.
Elevation of tuffs.
Tilting.
Basalt.
Chief faulting. (Affects everything preceding.)
Rhyolite (white) intrusion (probably Ararat, Oddie, Rushton hills).
  Vein formation. Primary minerals, quartz, chalcedony, calcite, siderite, pyrite.) Values low; gold and silver, gold apt to predominate.
Erosion.
Dacite intrusion (Butler, Brougher, Golden, Siebert mountains).
  Mineralization (chalcedony, manganese). Values slight to insignificant. Mud veins.
Erosion.
Glassy rhyolite flow (slopes of Oddie and Brougher).

DESCRIPTION OF THE ROCKS OF THE REGION.

Distribution and characteristics of the early andesite.—This was originally a hornblende-andesite, containing probably some biotite and pyroxene. In the immediate vicinity of Tonopah it outcrops only, so far as observed, on Mizpah Hill and Gold Hill, but it has been

discovered under younger rocks in a number of different mines, such as the Montana Tonopah, the North Star, the Ohio Tonopah, the California Tonopah, the Wandering Boy, part of the Fraction at least, and probably the West End and MacNamara, the Midway, etc. Nowhere is it in even an approximately fresh state, but, as before noted, it has altered largely to calcite and chlorite, and (more commonly in the vicinity of the veins) to quartz and sericite. In the former condition it has a fairly deep-green or blue color, while in the latter phases it is lighter green or blue, and very often nearly white, or assumes, near the surface and along faults or fractures, a pale yellowish, brownish, or reddish color. This common quartz-sericite type has the appearance of rhyolite rather than of anything else, and does not at all resemble andesite, while the calcite-chlorite phase has more nearly the rightful aspect of a highly altered andesite.

It is difficult always to distinguish this early andesite with certainty on account of its many different phases. It is most likely to be confounded with the later andesite on one hand and with certain types of rhyolite on the other. The main points of difference will be outlined shortly.

Distribution and characteristics of the later andesite.—The later andesite outcrops over a considerable region in the northern part of the district. The upper portions, and in some cases the whole, of the following shafts are in it: Montana Tonopah, North Star, Midway, Golden Anchor, Little Tonopah, Boston Tonopah, Halifax, etc. It varies greatly in state of preservation, being frequently found nearly fresh, and again highly decomposed. In its fresher phases it is a dark-colored, hard rock, with large crystals of pyroxene, feldspar, and biotite. It has usually been more or less altered, and as secondary minerals calcite, chlorite, serpentine, etc., have been formed, giving the rock a dark-green color. Frequently, also, the altered rock has a deep-blue color. Near the surface the red of the oxidized iron combines with these colors to produce a characteristic rich purple. In some places the rock has been thoroughly altered to calcite, chlorite, and pyrite, with other secondary minerals, and again has been so completely leached as to be soft and white.

In these highly altered phases the later andesite becomes with great difficulty distinguishable from the early andesite, and where it is fine grained the resemblance may become almost exact.

For the distinction of the two rocks in general it may be noted that the early andesite is characteristically finer grained than the later andesite, and that in the former the feldspar crystals are slimmer and rectangular, while in the latter they are stouter and often of complex shape. In some of the hornblende-andesite (though not generally) the long dark crystals of altered hornblende may be distinguished, while in the later andesite the crystals of biotite are usually plainly visible, even in the considerably altered phases. The characteristic later andesite has a coarse, mottled appearance, and even when highly

altered and bleached it has a dull clayey luster, which is rarely seen in the early andesite. Rocks which are highly siliceous from alteration are apt to belong to the early rather than the late andesite.

Distribution and characteristics of the rhyolites.—There have been several different rhyolite flows and intrusions, some before, some mainly subsequent to the faultings; and the rocks have a variety of appearances which defies any description in common. The lava of Oddie, Rushton, and Ararat hills is a characteristic siliceous white rhyolite. The Rescue shaft is mainly in this rock, and two long tunnnels, the North Star and the G. & H., have been driven in it into Mount Oddie.

Besides this, however, there is a formation of fine-grained gray or red, largely glassy rhyolite, which covers a still larger area. A large body of it occupies the northern portions of the district, where it is intrusive, with a sinuous contact, into the later andesite. It continues from here, along the western edge of the district, to the vicinity of the Ohio Tonopah, and occupies a considerable part of the basin inclosed between Butler, Brougher, and Siebert mountains. The formation here occurs as complicated dikes cutting the dacite-breccia formation, and as sheets underlying the tuff, or, to a less extent, intercalated in the tuff. In the rest of the district it is practically absent. It is in general between the dacite breccia and the stratified tuff in point of age, is older than the faults, and is therefore displaced by the fault movements. In the northern portion of the district a number of shafts are located on or near the contact of this rhyolite and the later andesite. Among these may be mentioned the King Tonopah, Belle of Tonopah, Miriam, Silvertop, Little Tonopah, etc. In the western portion the Ohio Tonopah and the New York Tonopah each encountered a considerable quantity of this rhyolite mixed with dacite breccia, while the Fraction extension is entirely in this rock, after having passed through the overlying tuff.

This finer grained gray or red rhyolite has many different aspects. Fine brecciation, with bright red, gray, and white colors, is frequent; in other cases it is dense and characterless. The best test of it is the detection of the small quartz crystals that dot the glassy groundmass, which distinguishes the rock satisfactorily from the andesites. Sometimes, however, these quartz crystals may be rare and small. Near the contacts of the rhyolite (intrusive into the earlier rocks) there has also frequently been alteration—silicification, the formation of pyrite, etc.—and then the rock may become almost identical in appearance with the early andesite which has been similarly altered. The best method for distinguishing the rhyolite from andesite in this case is the tracing of the connection with the less-altered rhyolite farther away from the contact.

Distribution and characteristics of the dacites.—The bold knob north of Butler Mountain, known as Heller Butte, is made up of what

is regarded as probably the oldest dacite exposed at the surface. It is a compact, relatively coarse-grained rock, finely brecciated, and carrying included fragments of older rocks, notably the later andesite. It is surrounded and probably overlain by the softer dacite-breccia formation. The Tonopah City shaft after passing through the dacite breccia has continued in solid Heller dacite to a total depth of over 500 feet. East of Butler Mountain, on the edge of the district, another strip of this dacite is exposed, also surrounded by the dacite breccia. It is regarded as probably intrusive.

The *dacite-breccia* formation, on the other hand, is essentially a surface formation, and not intrusive. It consists of flows of often very pumiceous and friable dacite, dacitic mud flows, and some rudely layered or even stratified fragmental material. In places it is very thick. It is exposed over a large fraction of the southern portion of the district, around Butler, Brougher, and Siebert mountains. The Ohio Tonopah and the New York Tonopah shafts passed through considerable thicknesses of this formation, and the Fraction No. 3 is entirely in it. The Fraction Nos. 1 and 2, and Wandering Boy, and the West End, passed through this formation at the surface and reached the underlying formations.

The *later intrusive dacite*, which makes up Butler, Brougher, and Golden mountains and the central portion of Siebert Mountain, has usually a characteristic appearance. It is darker than the rhyolite of Mount Oddie, has a slight purplish tinge, and contains more crystals (of feldspar, quartz, and mica) embedded in the glassy groundmass. The Big Tono shaft, at the east foot of Mount Brougher, starting at the outward-pitching contact of this rock and the intruded dacite-breccia formation, goes down several hundred feet in the former. The Molly, starting near the dacite contact on Golden Mountain, passed through several hundred feet of this rock, then through the inward-pitching contact to a slight thickness of loose material belonging to the dacite-breccia formation, and so into the later andesite.

PERIODS AND NATURE OF MINERALIZATION.

Mineralization subsequent to the early andesite intrusion.—The most important veins of the Tonopah district, and all those that have been proved to be of immediate economic importance, occur in the early andesite, and do not extend into the overlying rocks. Hence, when the early andesite is not exposed at the surface, the later rocks form a capping to the veins, and this capping must be passed through before anything can be learned of the presence or the nature of the veins beneath. This circumstance shows pretty plainly that the vein deposition took place before the eruption of the later andesite, and immediately after that of the early andesite (for the period of erosion between the two andesites seems to have exposed the veins at the surface, showing that they were formed before this period, or early in it).

Indeed, there is every evidence that the veins were formed by ascending hot waters succeeding and connected with the early andesite intrusion, and that these waters had apparently become inactive by the time of the later andesites.

The mineralization at this period was extraordinarily active, as the profound alteration of the early andesite testifies. Among the known veins formed at this period those of the Valley View, Mizpah, and Montana Tonopah groups are the most important, though certainly there are others which have not yet been discovered. These veins carry gold and silver, in the proportion of about 1 part of gold to 100 of silver, by weight. They are unusually free from base metals—no lead, arsenic, etc., has been detected. In some places there is a very little copper, in others none. The gangue is quartz, with frequently a mineral which is a variety of orthoclase feldspar (valencianite). The sulphide ores, so far as developed, show primary stephanite, with probably some polybasite, scant pyrite, and comparatively rare chalcopyrite. Secondary sulphides coating the cracks in these ores are ruby silver, argentite, and probably pyrite and chalcopyrite. The oxidized ores show abundant silver chloride, with occasional bromides, etc., and sometimes free gold.

Mineralization subsequent to the early rhyolite intrusion.—Along the borders of the gray or red glassy rhyolite intrusions, especially in the northern portion of the district, there has been, as before noted, considerable alteration and mineralization, which must be attributed to a cause similar to that which produced the veins in the early andesite—namely, the action of hot ascending waters immediately succeeding and genetically connected with the rhyolite intrusion. This alteration is in the form of silicification and the formation of pyrite, and has acted on the rhyolite as much as the intruded rock. Quartz veins have been formed, in the majority of cases relatively small. These veins contain precious metals, but usually very irregularly distributed. High assays, especially on the surface, may even be obtained, but it is likely that some of these are the result of the well-known process of increase of values at the surface during oxidation. Specimens of the veins have a general resemblance to those of veins of the early andesite, and show pyrite, often finely disseminated in a quartz gangue. Some of these veins have been found to be of considerable size; therefore it may often be difficult to distinguish them from the andesitic veins without study of the rock in which they lie. Chemically they appear to be characterized, so far as yet developed, by very low average values and by the frequent but not regular preponderance of the gold values over those of silver.

Mineralization subsequent to the later rhyolite intrusion.—It has been described how the white rhyolite of Oddie, Rushton, and Ararat hills is probably later than the dense, usually gray rhyolites referred to above. For example, the top of Ararat seems to be a plug or neck

of white rhyolite forced up into the earlier gray rhyolite. This later white rhyolite shows near its contacts, and to a less extent away from these, in itself or in the intruded rock, veins which are ascribed to causes similar to those which probably brought about the preceding mineralizations—namely, ascending heated waters following the lava intrusion, genetically connected with it, and, like the previous similar processes, dying out after the lapse of some time. These veins, which are in places very large, are of calcite, siderite or ferriferous calcite, chalcedony, etc. They contain some pyrite and sometimes give low values in the precious metals, gold preponderating.

Mineralization phenomena may also be observed in some places near the contact of the Oddie Mountain rhyolite, where there is silicification and the formation of pyrite, with quartz veins of various sizes, sometimes containing calcite. These veins are generally small, but may be large. Galena and chalcopyrite have been exceptionally found in them. They carry low values in gold and silver, the gold being apt to predominate.

Mineralization subsequent to the dacite intrusions.—Finally, the contacts of the large dacite necks (Butler, Golden, and other mountains) are accompanied in many places by the deposition of chalcedony, manganese, etc., in cracks and crevices. These are not usually in veins, or when so are small and irregular. Considerable values in the precious metals have been claimed in some cases, but it is the writer's experience that the content of these metals is insignificant.

Résumé.—To sum up, no fewer than four periods of hot-spring action, accompanied by more or less vein formation and mineralization, have been noted at Tonopah. Each of these periods was consequent upon a lava intrusion, and the mineralization was the result of a process which is known to accompany and follow volcanic eruption at the present day. In general, the values found in the veins of these different periods increase with increasing age. Also, the general phenomena indicate that the younger veins were formed nearer the surface than the older ones. Although ascending hot waters are not known to deposit more than traces of metals at the surface, it is supposed that an important precipitation takes place at some depth; so in the case of Tonopah it may be that the later periods of mineralization have produced some rich ores, but that erosion has not yet had time to expose the level at which they lie, whereas in the case of the oldest period this has been accomplished. At Gold Mountain, about 4 miles south of Tonopah, veins belonging to the rhyolitic period and having the same characteristics as some of these veins at Tonopah contain considerable values in gold and silver, while at Tonopah no such values have been discovered in this class of veins.

At Tonopah, therefore, the earliest and most important class of veins can be found only in the earlier andesite. The rhyolite veins, on the other hand, may occur in the rhyolites, as in any of the older

rocks; indeed, they must also occur sometimes in the early andesite itself. The mere fact of a vein lying in the early andesite, therefore, is not always evidence that it belongs to the early andesite period. In some such cases it may be extremely difficult, if not impossible, to tell to which period it belongs.

The later andesite is in many cases thoroughly decomposed and altered, and there has been extensive formation of pyrite, calcite, etc., in it, especially in the regions where the richest veins have been found. The nature of this alteration is such as to indicate copious percolating waters as the agents, and to suggest that the waters may have been heated. It is quite possible that some of the small sulphide-bearing veins, which are frequently found in the later andesite, may have been formed contemporaneously with this alteration. These veins are nonpersistent, and the values contained are small. Physically they resemble the rhyolitic veins, and as they have been noted chiefly in the general vicinity of rhyolite, which is intrusive into the later andesite, they have been classed with the undoubtedly rhyolitic veins. It is possible, however, that a moderate mineralization, similar in quantity to that which succeeded the rhyolite eruptions, followed that of the later andesite.

FIG. 1. Horizontal plan of portion of Mizpah vein, as developed on the 250-foot level, Mizpah mine, east of the Brougher shaft.

VEIN GROUPS OF THE EARLY ANDESITE MINERALIZATION.

The only productive veins thus far discovered in the Tonopah district proper are those of the early andesite period. On account of the later volcanic rocks which cover the early andesite in most of the district, these productive veins outcrop only in a very small area, outside of which little is known as yet. It is probable, however, as indicated by the great amount of alteration in the early andesite, that the vein formation has been extensive, and that the veins at present known are only a small portion of those that will eventually be developed.

The veins already discovered all belong to the type of "linked veins." Their physical characteristic is that they branch and reunite in both a horizontal and a vertical direction (fig. 1). There is generally in each group a main or master vein from which the smaller veins branch. These smaller veins again may subdivide and so finally

die out. The main vein and its branches may together be termed a "vein group."

Veins probably of the early andesite period have been discovered in various mines outside of Mizpah Hill, where the first discoveries were made. Among these later developments may be mentioned the California Tonopah, the MacNamara, the West End, the Ohio Tonopah, and other workings. But it is only the veins on Mizpah Hill

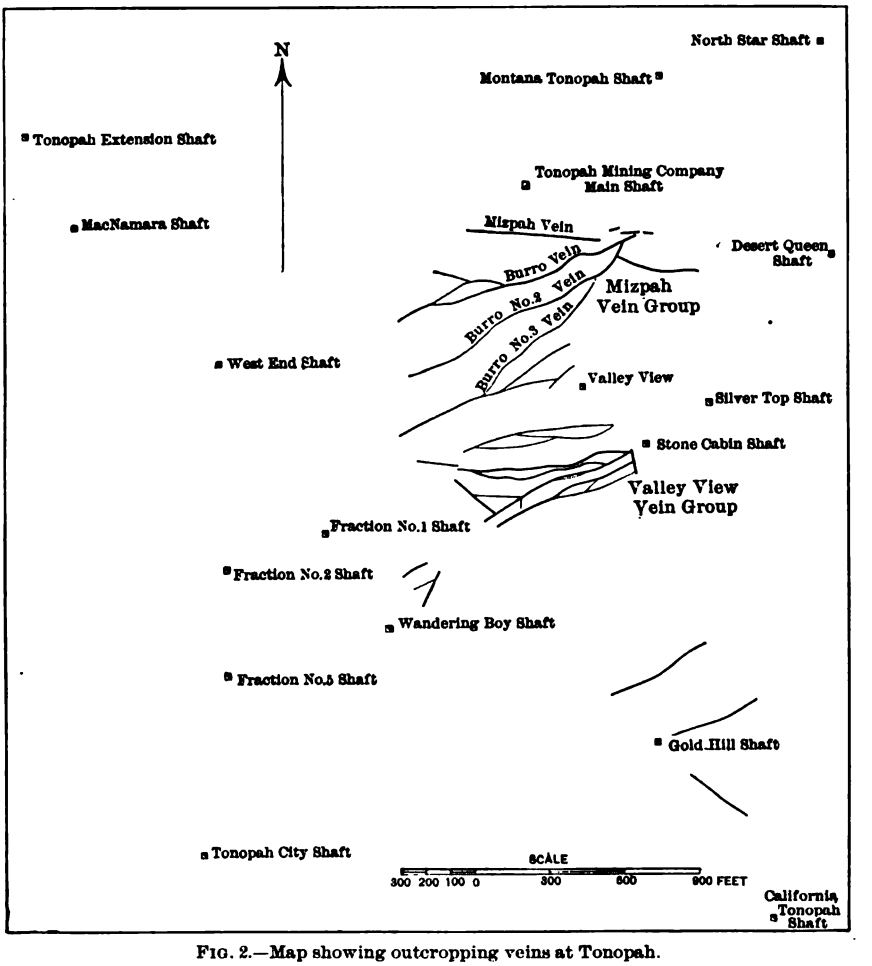


FIG. 2.—Map showing outcropping veins at Tonopah.

that have been sufficiently developed to give information concerning the vein system. On Mizpah Hill there may be recognized at present three main groups of veins—the Valley View group, the Mizpah group, and the Montana Tonopah group. These are all strong and distinct (fig. 2).

The Mizpah group lies in the center, between the other two, and was the first discovered. The trunk vein of the group is called the "Miz-

pah" vein, and crosses Mizpah Hill in an east-west direction, showing a strong outcrop. This outcrop is cut off both to the east and to the west by heavy faults, so that it is adjoined on the east by the rhyolite of Oddie Mountain and on the west by the later andesite. From the Mizpah vein a succession of branches depart, running chiefly in a southwestern direction from the eastern end of the outcrop, and each successive branch diverges more than its predecessor from the strike of the main vein, so that the whole group is like a section of the spokes of a wheel, the spokes uniting some distance east of the main shaft. The chief of these branches are known as the Burro No. 1, No. 2, No. 3, etc. They are strongest near the main vein, and those which diverge most from the strike of the latter are weaker than those which are more nearly parallel to it. The intersections of the branches with the main vein and with one another usually pitch to the east at a moderate angle. These easterly pitching intersections are significant, since they have the same general course as certain shoots of especially rich ore in the same vein, and correspond also in direction to some post-mineral fracturing and faulting. The main vein has in general a steep northerly dip, which is locally overturned so as to dip steeply to the south.

The Valley View mine shows a group of veins of the same general type as the Mizpah, but with minor differences. The main Valley View vein as exposed in the workings has, like the Mizpah vein, a northerly dip, but is very much flatter. It is very large, and the rich ore in it is unequally distributed, occurring in shoots or bunches. As the large vein approaches the surface it splits into several somewhat smaller veins, which assume a nearly, or quite, vertical position. This vein group is in general very nearly parallel to the Mizpah group; the linked character, forking and reuniting, is quite as well marked as in the Mizpah group; and there is some radiation in the strike of the veins, although not so much as in the former case. The Valley View veins are affected by post-mineral faulting, like the Mizpah vein.

The Montana Tonopah group shows a strong main vein running east and west and dipping north at a moderate angle. A number of lesser veins have been cut in the workings, and although development at the time of the writer's examination was comparatively slight, it is probable that most of these veins will eventually unite with one another or with the trunk vein. The indications are that the branches lie mostly on the north side of the trunk vein and diverge in trend from it, opening out to the east. These branches as a rule dip more steeply than the main vein, and will, therefore, also tend to unite with it vertically. The Montana Tonopah veins are, like the others, displaced by considerable post-mineral faulting.

In all these veins the union of two branches to form one is generally attended by corresponding enrichment, and, conversely, the place

where a small branch vein leaves the main one is generally impoverished, often to a much greater degree than the size of the branch vein would seem to warrant. The recognition of this fact by the miners has led to the use of the highly descriptive term "vein robbers," for these small branches.

From the above it will be seen that the chief developed Tonopah veins have a decided east-west trend. From the fact that there is a predominant north-south trend in some of the chief veins of California and the western part of Nevada, east-west veins have been looked upon with some prejudice in Tonopah, many miners being inclined to doubt the value of the veins on account of their strike, and others forming the theory that they were simply the offshoot of a great undiscovered north-south vein which would prove to be vastly richer than these; but the Tonopah field is in an entirely different region, geologically, from California, and this objection seems to the writer to have little weight. In Idaho, where the geological conditions are perhaps more like those of Nevada than they are in California, the usual trend of the veins is east and west.

Minor veins run northwest and northeast and even north and south, but so far as yet observed the east-west veins are the chief ones, and it seems likely that the mineralization will be extensive in an east-west belt rather than in a north-south one.

OCCURRENCE OF ORES IN THE VEINS.

Physical character.—The veins of the Tonopah district are usually strong, straight, and well defined, yet they are not fissure veins. They have at first sight all the appearance of fissure veins, but a little close examination shows that they have been formed almost entirely by replacement of the andesite in which they occur. They seem to have originated along zones of especially strong fracturing in the andesite, formed during a period of movement subsequent to the consolidation of this rock. These zones of maximum fracturing, which are usually 4 to 6 feet wide, but may be much wider or narrower, became the chief channels of circulation for the mineralizing waters. It has already been stated, in describing the alteration of the early andesite, that the andesite near the veins has been silicified to a very great extent, and the veins themselves seem to be the final stage of alteration, the andesite being mostly or entirely altered to quartz. A slight detailed study of the veins gives abundant proof of this origin, for all stages in the development can be seen in different portions. In many cases the vein consists simply of a zone of more or less altered andesite, not essentially different, except perhaps for a somewhat greater silicification, from the andesite which forms the walls. This zone is cut by parallel fractures having the same strike and dip as the walls, and the walls themselves are nothing more than stronger fractures of the same kind. In the next stage, where part of this fracture zone becomes

altered to quartz, the main wall fractures have been the most favorable, so that sometimes a hanging-wall streak of quartz and a foot-wall streak are found with only altered andesite between (fig. 3). Sometimes, also, either the hanging-wall or the foot-wall streak may be wanting. Next, streaks of quartz parallel with the walls may be found, or the quartz may form a network in the andesite. Thus the process may be traced to the stage where the whole of the andesite is replaced by quartz, forming a solid vein several feet in width. As a

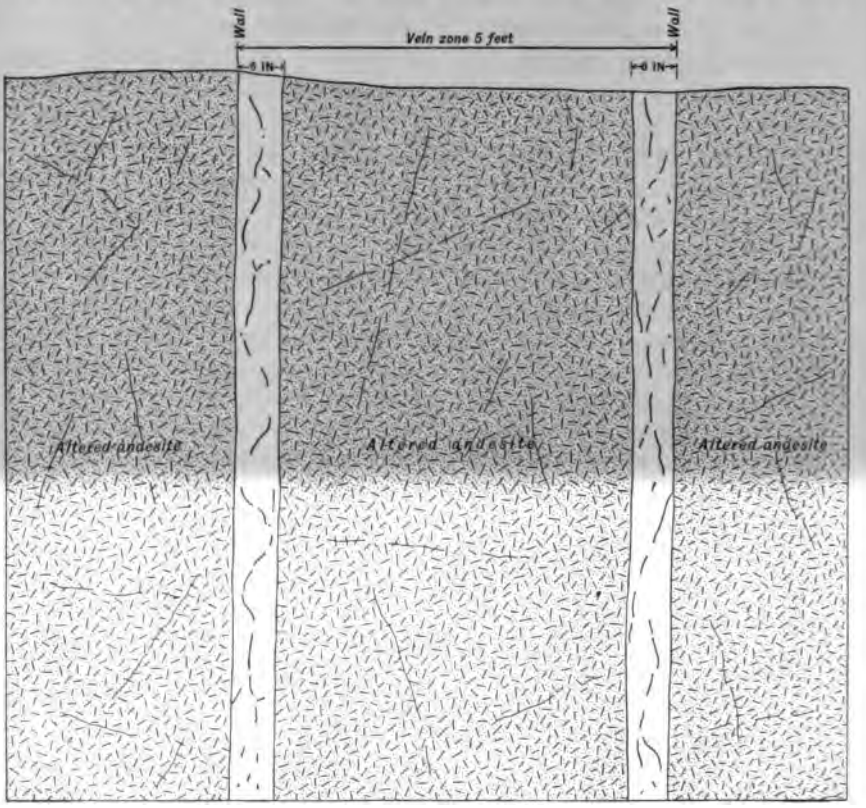


FIG. 3.—Detailed vertical section of one of minor Valley View veins at surface.

rule, however, there is more or less decomposed andesite forming part of the vein.

As exceptions there are found streaks of quartz, usually small, within the vein, which show crustification and comb structure, and thus bear evidence of having been formed in cavities. These cavities, however, were of irregular shape and were not fissures, properly speaking, but spaces of dissolution, and were the effect of the mineralizing waters themselves.

The largest example of a crustified vein is found in certain parts of the Montana Tonopah workings, where the cavities were sometimes 2 or 3 feet in diameter and gave rise to well-banded ores.

In the Montana Tonopah the chief vein shows in places a brecciation and subsequent cementation. Both the original material and the subsequent cement are of quartz and rich black silver ores, and seem to have been deposited under about the same conditions. The inference is that the strain which originally produced the fracture zones kept on during their cementation by the circulating mineralizing waters, and that in this case this strain resulted in the local shattering of the cement and the subsequent healing by similar materials.

Primary ores.—At the time of the writer's first investigation of Tonopah, in the autumn of 1902, only the oxidized ores of the upper levels of the Mizpah were available for examination. From a microscopic study of these he found that the original metallic mineral was still present in minute grains. It was black in color, and he supposed it to be a rich silver sulphide. Subsequent to this investigation the primary sulphide ores were found in the Montana Tonopah mine, and the correctness of the forecast above mentioned was shown. In the Montana Tonopah the ores are quartz veins carrying in places very large amounts of the rich black antimonial sulphide of silver, stephanite. This stephanite is undoubtedly primary. Besides the quartz, as gangue mineral, there is another having a milky appearance, but otherwise looking much like the quartz. This is a variety of orthoclase (valencianite). Some of the stephanite may contain some copper, making it a kind of polybasite. Chalcopyrite is very commonly present and is probably, in part at least, primary, although this is not certain.

Secondary sulphides.—Throughout the Tonopah district argentite and ruby silver occur in greater or less abundance, sometimes adding considerably to the value of ores, but they do not occur in such quantities as the stephanite ores or the oxidized products. Wherever found the argentite and the ruby silver are unquestionably secondary, having formed from the alteration of the stephanite. They occur along cracks in the primary sulphide ore and are occasionally found in the oxidized or semioxidized ore. The chalcopyrite above mentioned, as observed in the Montana Tonopah ore, seems to occur chiefly as small streaks cutting the original stephanite ore, giving it the appearance of being secondary to the latter. In some cases it occurs along cracks and is undoubtedly secondary. It is very likely that some at least of this mineral has been formed from the copper contained in the cupriferous silver sulphide. Some pyrite is also undoubtedly secondary. Pyrite, however, is relatively rare in these ores—much more so than in the country rock.

Oxidized ores.—In the Mizpah vein the oxidized zone extends nearly down to the 700-foot level. Observation shows, however, that the limit of oxidation is extremely irregular. For example, the oxidation extends much deeper along the vein than some distance away from it

in the country rock. At 400 feet from the surface the Valley View veins show oxidized ore, while 100 feet higher the country rock away from the veins is unoxidized. In the Stone Cabin shaft the change from the oxidized to the unoxidized andesite came just below the 200-foot level, but at 400 feet the ore is partly oxidized. The reason for this appears to be that the quartz veins, on account of their brittleness, have been more readily fractured by strains than has the softer country rock, and so the veins afford channels for oxidizing waters coming from the surface. Strong fractures, such as those in the vicinity of faults, have the same effect as the open fractures in veins and carry down the oxidizing influences to a depth of several hundred feet. Where the rocks are protected above by relatively impervious formations the oxidation may be comparatively slight. Thus, in the Silvertop workings (near the Stone Cabin) the later andesite is unoxidized at a depth of 120 feet. Here it is protected at the surface by a deposit of fine-grained, stratified tuff.

In the oxidized zone of the veins the sulphides are mostly entirely altered or can be made out only with a microscope, yet in many cases the alteration is not complete and the purple color of the richer quartz is as a rule due to these finely disseminated sulphides. Most of the sulphides, however, are altered to silver chloride, with some bromides and iodides, and to iron oxide. Nearly all of the ore in the Mizpah vein, down to the lowest depths explored, is oxidized, while the ores of the Montana Tonopah are only slightly and exceptionally oxidized. In the latter case the veins and the inclosing early andesite have been protected from the atmosphere by several hundred feet of decomposed, soft, later andesite, whereas in the former case the veins outcrop at the surface and oxidizing waters sink readily into them.

In the process of oxidation and alteration of the metallic minerals there has probably been some transfer of material. Little is known of the primary or unoxidized veins, but some portions seem almost entirely barren and some very rich. It will probably be found that these rich portions form definite shoots or masses of ore in the relatively barren veins. In the oxidized ores the values are by no means uniform, but seem rather better distributed than in the deeper regions. The indications are that during oxidation some of the values have been distributed from the richer portions through the more barren portions, producing a larger supply of fair quality ore. It is also likely that during this process there has been some concentration of values, so that the oxidized ores as a whole may be found to be somewhat richer than the sulphide ores. It is possible, for example, that those portions of the veins which have been eroded furnished during the process of erosion a small share of their precious metals to the underlying portions of the vein, these underlying portions now having become the present oxidized zone.

It also seems probable that in places some relatively slight transfer and redeposition of the precious metals has taken place along

the fault planes, which are later than the original veins and have displaced them. This action, however, is only exceptionally the case, and as a whole is insignificant. The main ore shoots of the oxidized portion of the Mizpah mine are regarded as primary, since evidence has been found that these coincide with the original ones and have been oxidized nearly in place; therefore it is improbable that the transfer of material during oxidation, bringing about local concentration or impoverishment, has been very great.

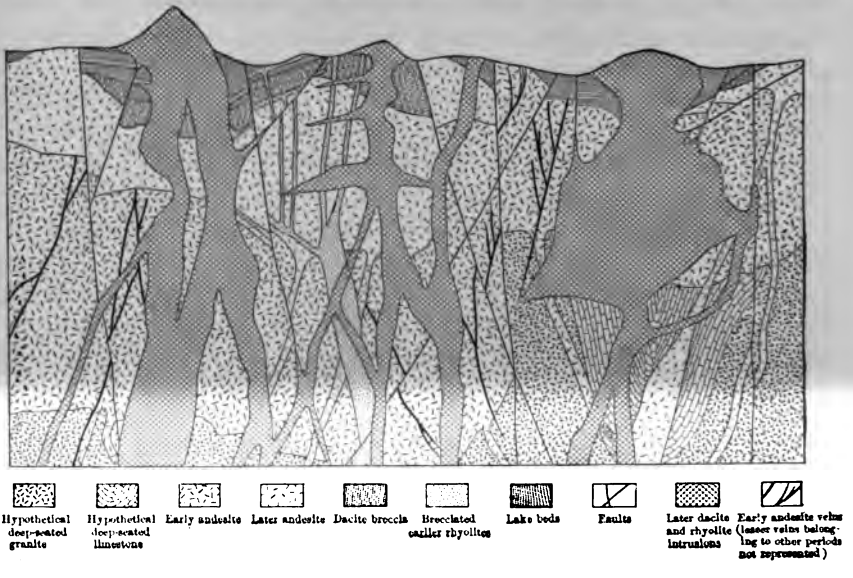
Ore shoots.—In the oxidized portion of the Mizpah vein the richer ores lie in roughly defined, broad shoots, which pitch east on the vein. At least three of these shoots, parallel to one another and with poorer ore between, have been recognized. In the unoxidized ores of the Montana Tonopah there is evidence of the existence of similar shoots or bunches, but enough exploration work has not been done to enable the writer to describe them more closely.

APPLICATION OF GEOLOGICAL PRINCIPLES.

From the short description of the occurrence of the veins which has been given, it is seen that it is of the first and highest importance to distinguish and determine, so far as possible, the position of the early andesite. As has been noted, this early andesite is likely to be confounded with the later andesite and with some forms of altered and silicified rhyolite, especially that gray, glassy rhyolite which occupies a considerable area in the northern corner of the district. As is seen on the accompanying map, the actual area where the early andesite outcrops is very limited, and in other portions of the district it is covered by later rocks or is cut through and displaced by them. These later cappings may consist of the biotite-andesite, the various rhyolites and dacites, the volcanic breccias, or the stratified tuff formation; or they may consist of two or more of these, superimposed one on the other. Those later rocks which are intrusive rather than in the form of flows (including some of the siliceous rhyolites, some of the dacites, and probably even some of the later andesites) can not be expected, however, to give way to the early andesite in depth. A shaft sunk in a dike or volcanic neck is very apt to continue in this same rock indefinitely downward (see fig. 4).

Of the different rocks which cap the early andesite and the included veins, the oldest, the later andesite, is regarded as the most favorable for prospecting; and, in the light of present knowledge, a belt of this rock lying east and west of Mizpah Hill is probably especially favorable. On the other hand, although the veins indicate a general east-west trend of mineralization, it is by no means proved that the outcrops on Mizpah Hill occupy the center of the mineralized belt and show the greatest mineralization. It may eventually be proved that the strongest portion of this belt lies north or south of the locality known at present, which would make the whole width of the belt con-

siderable. The whole later andesite region is worthy of careful yet cautious prospecting. The localities where the later andesite is intruded by the rhyolite ought, as a rule, to be avoided in this prospecting, for such places are not so favorable as those where the andesite is undisturbed. Such places, however, are likely to be preferred by many mining men, since they are apt to show some of the smaller and poorer veins of the later rhyolitic mineralization. Again, the region of faults should be avoided, for these faults have affected the ore-bearing veins, and if veins are found near them they are difficult, and sometimes almost impossible, to follow. The rocks along fault zones are often decomposed and the decomposed material may



have the appearance of what is known as "vein matter." From this material real or fictitious assays may be obtained, and such a locality may appear to the miner as more hopeful than less altered rock which does not look like a vein and does not show any assays. Some of the principal faults are shown on the accompanying map, but certainly not all of them have been detected, and underground developments will probably reveal many more.

Concerning the dacites and rhyolites of the later intrusions, the volcanic necks and the dikes should, as a rule, be avoided by prospecting operations. The greater parts of the principal low mountains and hills in the vicinity, such as Butler, Brougher, Siebert, most of Golden, etc., are regarded as offering very little hope for prospecting, and even near the rhyolite hills, like Rushton, Oddie, and Ararat, there has been a displacement of the veins, for the hills are essentially intrusive. The writer is aware that the proximity of the rich veins of Mizpah Hill to Oddie Mountain has caused this mountain to be

regarded with great favor, but the fact that the veins are in this position has no connection with the mountain; they are there rather in spite of the mountain than by virtue of it, and it would certainly have been much better for mining operations if the rhyolite had not been erupted and the mountain formed.

Most of the dacite breccias and some of the brecciated rhyolite are in the nature of flows, and may be sunk through by shafts to lower formations, such as the later andesite or the early andesite. Much of the fine-grained, brecciated rhyolite, however, is intrusive, so that, as a rule, this rock also is not a good place to sink, except with caution.

The tuff formation, of course, is always sedimentary and can be sunk through to reach the underlying formation, which may be any one of the older rocks.

To sum up, then, the later andesite is the most favorable of the capping rocks; the pumiceous dacite breccia with interstratified, coarse, tuffaceous rocks is next, while the brecciated rhyolite should be prospected very cautiously to see whether it is intrusive. The tuff may be pierced to discover the underlying rock where the geological relations do not make this plain, while intrusive dacite and rhyolite necks should be approached very cautiously indeed.

It must be understood that these characterizations apply only to the immediate vicinity of Tonopah, or the Tonopah district proper. On account of the sudden rise and fame of the camp the name Tonopah has spread far beyond its limits, and has been applied to mines lying in quite other districts, sometimes 50 or 60 miles away. Here, and also in neighboring districts which have not borrowed the name Tonopah, the geological conditions are different. In the Gold Mountain district, for example, about 4 miles south of Tonopah, the veins lie in rhyolites and tuffs and evidently belong to the rhyolitic period; yet they carry in some cases considerable values in gold and silver.

The position of the early andesite away from the outcrops can be foretold to only a limited and uncertain extent, for in dealing with a complex of volcanic flows and dikes like that in Tonopah there is no rule which governs their distribution and by which their position in an unknown locality can always be defined with certainty. Therefore, the prospecting should be done cautiously and the district should be developed from the known region as a center; thus little by little a greater knowledge of the geological detail will be gained. On account of the lack of certainty of results in this work, in many cases it would probably be more economical, both of time and of money, to explore with a diamond drill rather than with shafts. Certainly the sinking of a two- or three-compartment shaft in an unproved portion of the district is often unwise.

The early andesite once located, the question of finding the veins remains, and after that the question of finding pay ore within the veins. The geological evidence goes to show that the mineralizing

waters which produced the early andesite veins were unusually active, and a large amount of vein formation is indicated. It is beyond question, therefore, that the veins thus far found are only a fraction of those which exist in the vicinity. These veins will be chiefly unoxidized, since they are protected from oxidation by capping rocks. In them undoubtedly large portions—probably much the larger portions—will be relatively barren quartz, in which shoots, chimneys, or irregular bunches of rich ore may be expected to a considerable depth.

These quartz veins, carrying silver and gold and occurring in Tertiary andesite, belong to a larger group of veins occurring in similar andesite and found along a north-south zone. These veins are exemplified by the Comstock in Nevada and by the important district of Pachuca in Mexico. Probably Pachuca is the nearest analogue, and its description, as given by the Mexican geologist, Ordoñez, may be of value in considering the characters of the Tonopah veins. Judging from these districts it is possible that in depth a rather larger proportion of the baser metals, such as copper, and possibly lead and zinc (although no traces of the last two have as yet been found in the veins), may come in, and that the values in gold and silver may decrease somewhat. This, however, if it happens, should do so at a considerable depth.

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[Bulletin No. 219.]

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